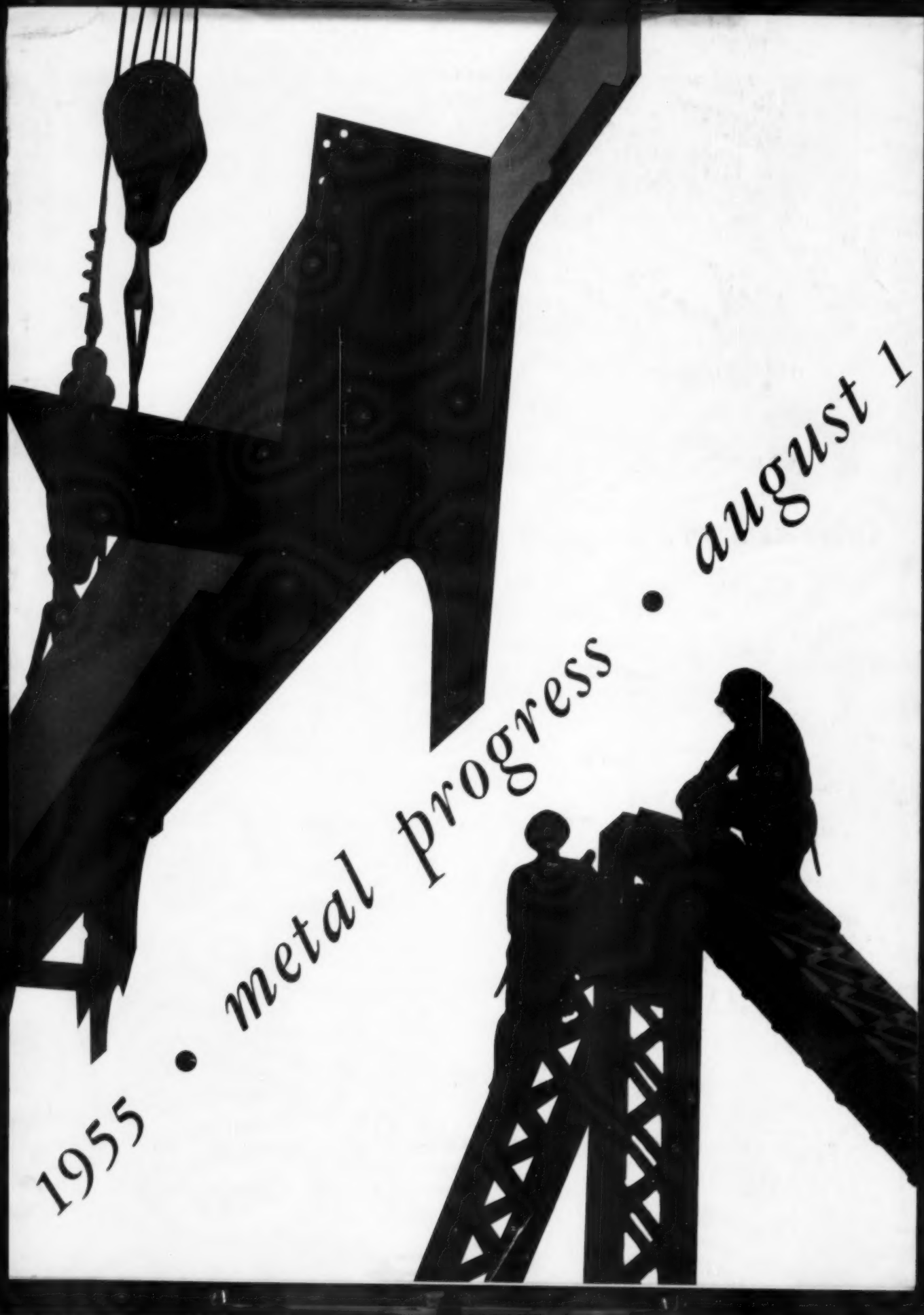
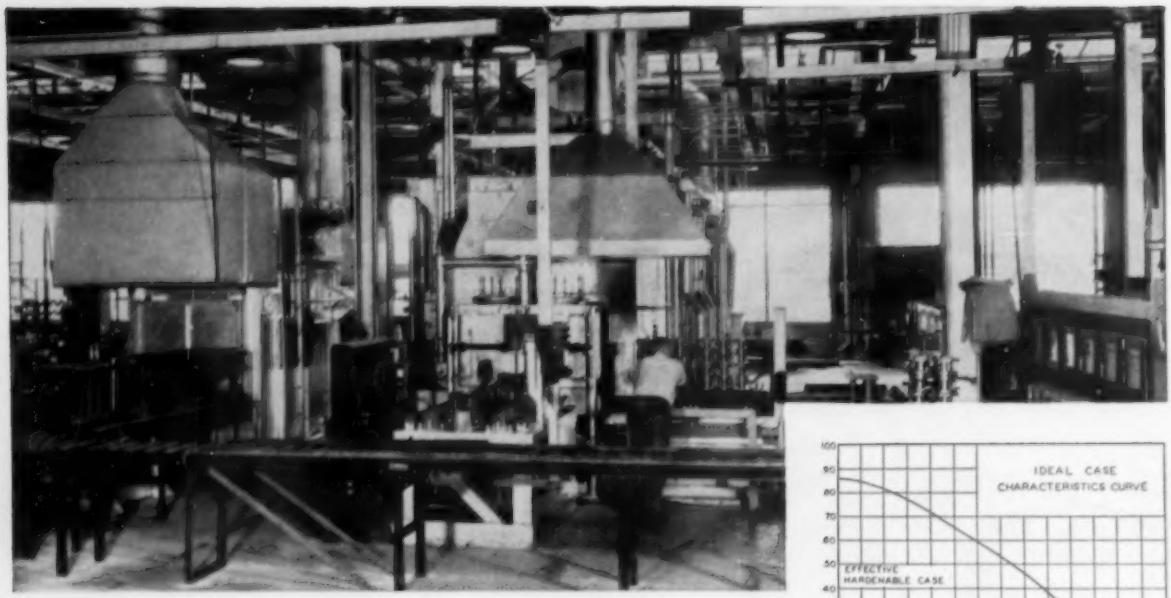
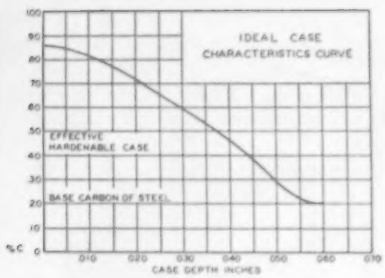
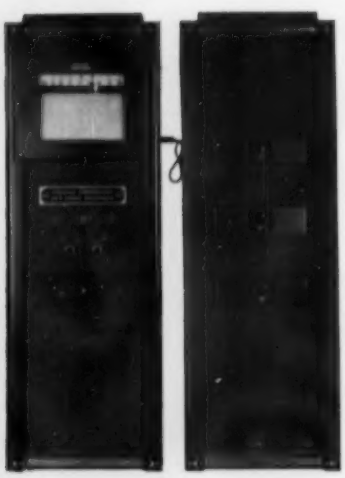

1955 • metal progress • august 1





on the nose every time

WITH SURFACE AUTOCARB AUTOMATIC CARBON POTENTIAL CONTROL



New high physicals in carburized gears—better tooth-to-tooth and gear-to-gear uniformity—faster cycles—automatic compensation for changes in work surface area during furnace operation . . .

These are the chief benefits Warner Gear Division, Muncie, Ind., achieves in its most recent continuous gas carburizing line, using the 'Surface' fully automatic carbon potential control system. In a nutshell: The Surface dewpoint recorder-controller periodically checks carbon potential in each of three zones in the furnace (with a range of .3 to 1.1% carbon), controls mixing valves to deliver correct additions of air or gas to maintain desired carbon potential in each zone. This system eliminates the human element in controlling carbon potential. It also provides Warner Gear with the necessary close control required for the practical carburizing of gears with near-eutectoid surface carbon concentrations.

Write for Literature H-54-2.

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Metal Progress

Volume 68, No. 2

August 1 . . 1955

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ERNEST E. THUM, *Editor*
FLOYD E. CRAIG, *Art Director*
MARJORIE R. HYSLOP, *Managing Editor*
HAROLD J. ROAST and E. C. WRIGHT, *Consulting Editors*

Two issues of *Metal Progress* will be sent to all A.S.M. members and subscribers in August. This one, dated August 1, 1955, has the usual editorial direction. The second one, dated August 15, 1955, will be confined to reports of A.S.M. technical committees, and can be used to supplement the 1948 edition of the A.S.M. Metals Handbook.

Cover by RICHARD PROCHASKA

Engineering Articles

Impact Failure of Gear Teeth, by Arthur J. Kauper 73

Failure of transmission gear teeth was traced to variation in impact strength that followed the ingot pattern in the bar stock from which they were made. (Q6, ST)

Applications of Arc-Cast Molybdenum, by N. L. Deuble 77

Molybdenum is currently going into production of magnetron tubes and glass melting furnaces; nearing commercial usage are piercer points for the tubing industry, die-casting dies, ramjet nozzles and gas-turbine parts. (T general, Mo)

Drawing Failures in Extruded Shells, by Hubert J. Pessl 80

The cause of a steadily increasing rate of drawing failures of cold extruded 75-mm. shells could not be found until the punch broke. Failure was due to fatigue originating at a "flake". Stresses in drawing had caused the punch to increase in diameter and pinch the shells. (F24, S21, TS)

The Supply of Metallurgists With Graduate Training, by Michael B. Bever 82

The number of Masters' degrees in metallurgy granted in the U.S. hit a peak in 1950 and 1951, dipped sharply in 1952 and 1953, but is on the way back up. In the same period the number of Doctors' degrees has shown a steady upward trend. (A3)

Controlling Corrosion With Cathodic Protection, by H. R. Ludeker 86

Corrosion can be controlled by interposing an electrical resistance in the corrosion circuit or by limiting the difference in potentials of the anodic and cathodic areas. (R10)

Hardenability of Carbo-Nitrided Carbon Steel, by R. H. Marshall 91

Increase in grain size or manganese content increases hardenability of carbo-nitrided carbon steels. The effect of grain size is greater than the effect of manganese in the range investigated. (J26, ST)

4000° F. Gas Furnace, by Horace B. Drever 94

A completely automatic gas-fired furnace developed in England is capable of continued operation at 3200 to 4000° F. using air rather than oxygen for combustion. (J general)

Applications of Powder Metallurgy, Reported by Pol Duwez 97

Five papers presented at the Western Metal Congress last March indicate the wide range of applications of powder metallurgy throughout industry. (H general)

Cotton Picker 100

A pictorial story of the fabrication, heat treatment, and finishing of rotating spindles for a mechanical cotton picker. (G general, J general, L17)

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Published monthly except bi-weekly in August, by AMERICAN SOCIETY FOR METALS. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00. . . . The AMERICAN SOCIETY FOR METALS is not responsible for statements or opinions printed in this publication. . . . Requests for change in address should include *old* address of the subscriber; missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of date of issue. No claims allowed for overseas subscribers. Entered as second-class matter at the Post Office in Mt. Morris, Ill. Copyright, 1955, by AMERICAN SOCIETY FOR METALS.

THERMALLOY* APPLICATION ENGINEERING AT WORK

The Curtiss-Wright turbo-compound aircraft engine, showing the valve guide which is cast of an Electro-Alloys anti-galling, heat and abrasion-resistant alloy. This engine is used in many powerful transport aircraft.

This special alloy resists abrasion . . . at high temperature

The original problem arose when Curtiss-Wright Corporation, Wood-Ridge, N. J., required an alloy for valve guides which would reduce oxidation at high temperatures and improve valve stem durability. The Electro-Alloys metallurgical staff tested many alloys, selecting the one proved best for the job.

It is a hardenable, machinable, cast alloy which resists oxidation up to 1800°F (982°C), and it can be drilled or tapped. This alloy has excellent abrasion resistance. It is being used with particular success in valve guide applications. This same alloy is also being used in pump shells, burner nozzles and other parts which must resist heat and severe abrasion.

Their work in new alloy development and extensive experience in the application of existing alloys to solve complex problems qualify the Electro-Alloys engineering and metallurgical staff for tough assignments. If you face the need for high heat-resistant castings, call our nearest representative, or write to us in Elyria.

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New Developments in Metallurgy, by Bruce S. Old 105

Since 1938 metallurgists have been in part responsible for major advances in nuclear energy, gas turbine development, electronics, steel melting and many other fields. They have in turn benefited from the interchange of ideas with other branches of engineering which also have contributed to these developments. (A general)

Teflon-Impregnated Bearings for Service in Water, by H. B. Nudelman and Cord H. Sump 112

Porous stainless steel bearings impregnated with Teflon are recommended for service where hot water is used for lubrication. (T7, SS)

Sodium Hydride Descaling of Titanium, by W. J. Barth and A. L. Feild, Jr. 114

When sodium hydride is used to descale titanium, hydrogen will be absorbed by the metal as soon as the scale is entirely removed. (L12, Ti)

Critical Point

Pattern for Progress 96

Research requires a fine balance between direction of effort and freedom from supervision. Such a balance is constantly sought in the research laboratories of Electro Metallurgical Co. (A9)

Atomic Age

"Atoms for Peace" Program 104

In his commencement address at Pennsylvania State University, President Eisenhower presented two new proposals for participation by free nations. Some supplementary remarks at the United Nations anniversary meeting are pertinent.

Book Review

Copper – the Industrial Picture and Supply Problem, reviewed by R. G. Thompson 117

"Copper–the Science and Techology of the Metal, Its Alloys and Compounds", edited by Allison Butts, is a reference text of broad scope written by 43 leading authorities.

Correspondence

Hydride Modified to Reduce Hydrogen Absorption, by Q. de L. Wheatley 119

Proposes a method of overcoming the problem of hydrogen absorption by titanium in sodium hydride descaling.

Emancipation From Slavery to Noughts, by T. Henry Turner 119

Urges the streamlining of printed figures for tensile tests and chemical analyses.

Data Sheet

Hardenability Bands for Tentative Standard H-Steels, Boron-Treated 104-B

Last of a series of eight sheets translating into simplified chart form the hardenability curves and data issued by the American Iron and Steel Institute.

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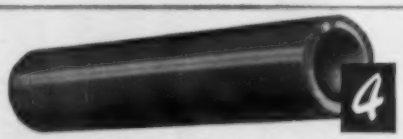
7 WAYS to SAVE MONEY with TOCCO* Induction Hardening

Cost was reduced 94% when heat-treatment of this corn-harvester part was changed from carburizing to TOCCO-hardening, 9½c saved on every piece — $4750 on each 50,000 piece batch, plus an hourly production increase from 120 to 300 pieces per hour.

Leading automotive companies need and use TOCCO hardened axle shafts to handle higher horsepower. Better, yet cheaper—savings of $375.00 per day. Less machining costs, lower priced material, increased production, and a plus in quality—200% greater torsional life.

Kearney & Trecker Corp. reduced the cost of hardening this milling machine part from $1.57 to 10c apiece. In addition TOCCO made possible a switch from alloy to S.A.E. 1045 steel—saving another 11c per piece in material cost. Kearney & Trecker hardens 140 different parts on one TOCCO unit.



Thompson Products Ltd. boosted production of these automotive wrist pins from 500 to 1200 per hour when they switched to TOCCO-hardening. Costs fell from $5.45 to $3.25 per hundred parts—a savings of 2c per pin, $26.40 per production hour.

Mechanics Universal Joint Division of Borg-Warner reports a 69% savings in the hardening of stub ends for propeller shafts. TOCCO also upped production from 35 to 112 parts per hour—over three times as fast as conventional heating methods.

Lima-Hamilton Corporation adopted TOCCO for hardening this shifting lever. Results: a savings of 4c per piece—$25 per production hour. TOCCO costs only 17% of former heating method. This is only 1 of 139 parts TOCCO-hardened by Lima-Hamilton Corp. All show savings over usual heating methods.

7

Number 7—the lucky number—is up to you. Why not add your name to the list of companies who use TOCCO Induction Heating to increase production, improve products and lower costs. TOCCO engineers are ready to survey your plant for similar cost-saving results—without obligation, of course.

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As I was saying...

HERE is a message I gave to the Third General Assembly of the Iron and Steel Institute of Spain last month:

"Dear Mr. President: I consider it a great honor to have been designated by the Board of Trustees of the American Society for Metals to bring to you and to the members of the Instituto del Hierro y del Acero congratulations and best wishes for another successful General Assembly.

"The American Society for Metals has observed from afar the outstanding success of these assemblies and is more than happy to have an opportunity to express its admiration in this positive manner.

"The delaying of the opening of your Third General Assembly to permit scientists attending the Joint Metallurgical Societies Meeting in Europe to attend your meeting is indicative of the fine spirit that has permeated the correspondence with your Institute.

"The results of the First World Metallurgical Congress in Detroit in 1951 as well as the subsequent international conferences just completed have demonstrated to all that the metal scientists of the world, having an established community of interest, will continue these joint meetings, since they have provided not only an exchange of information but have brought about the establishment of firm and lasting friendships among metalmen of the free world which guarantee so much toward the peace of the world.

"I have been authorized by the Board of Trustees of the Society to extend to you an invitation (as will be extended to other metallurgical organizations) to participate and send conferees, as many as you may wish, to the Second World Metallurgical Congress which will be held under the auspices of the American Society for Metals in the United States, in Chicago, Nov. 2 through 8, 1957. More complete details will, of course, come to you at a later time.

"Mr. President, so that there may be an indication of the desire of the A.S.M. for a continuation of helpful cooperative activities between our organizations, I have the authority and the honor to transmit herewith an Honorary Life Membership in the American Society for Metals for your able and efficient director, Mr. Augustin Plana-Sancho."

In addition to Spain, invitations to participate in the Second World Metallurgical Congress were personally extended to the metal scientists of Great Britain, Germany, Belgium and Italy. Formal invitations will be sent soon to all free countries. We hope they will all come to America in 1957.

Cordially,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

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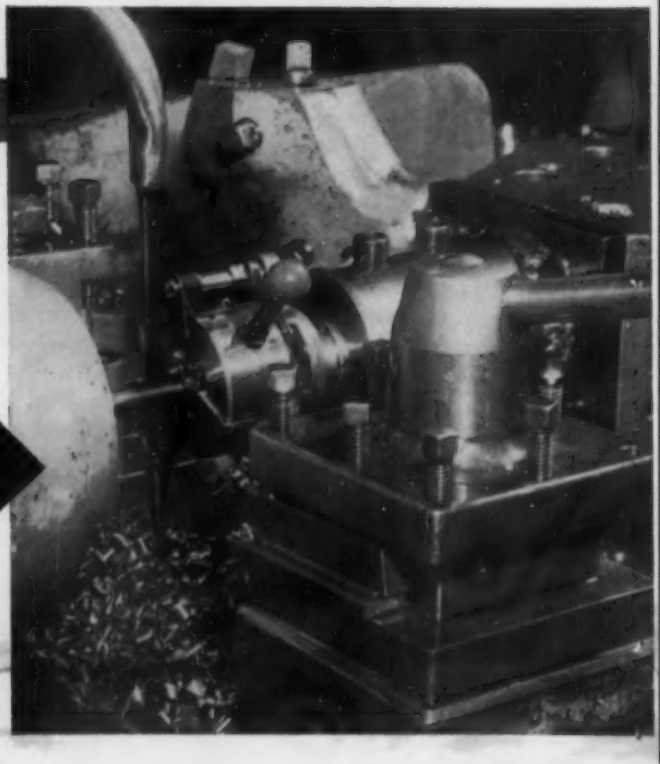
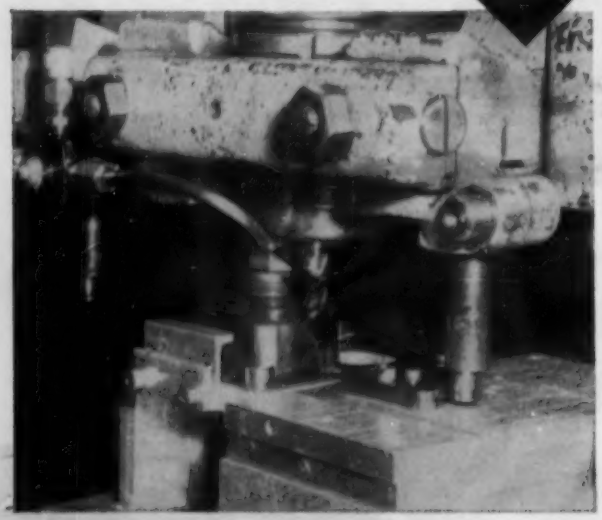
"We found the key to successful machining of ti-stainless--

GULF ELECTRO CUTTING OIL"

says Mr. D. E. Gillmor, Vice President of Gillmors, Inc., Long Island, N.Y.



Improved machining practice on ti-stainless quickly followed a switch to Gulf Electro Cutting Oil in this shop, with results like these: from 20 pieces per tool grind to as many as 45; and finish improved about 43 microns—from 63, the best obtainable with other cutting oils, to as low as 15. For additional information, see page 144 of the September 13, 1954 issue of American Machinist.



Gulf Oil Corporation · Gulf Refining Company

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"We increased our tool life 40% and improved the finish 43 microns"

Mr. D. E. Gillmor, Vice President of Gillmors, Inc., Gulf Assistant District Manager Don Gallaher, and Mr. George Glaeser, General Foreman of Gillmors, examine several of the ti-stainless parts machined with Gulf Electro Cutting Oil.

"WE tried scores of cutting oils over a period of months in an effort to increase tool life and get a better finish in machining type 321 titanium stainless steel. Then a Gulf Sales Engineer recommended Gulf Electro Cutting Oil.

"Right away results were phenomenal. Tool life was increased over 40% and surface finish was improved 43 microns."

Gulf Electro Cutting Oil has proved to be the answer to many tough machining problems like this. It contains both free sulphur—held in stable solution—and sulphurized mineral oil, in which the sulphur is chemically combined by an exclusive Gulf process. This combination provides high sulphur activity over the entire range of a cutting operation—gives the tool maximum protection and helps to reduce built-up edge. It also has excellent anti-weld characteristics and extreme load carrying ability.

And remember that Gulf provides a complete line of quality cutting oils that will help you get improved production and longer tool life in all your machining operations. Write, wire, or phone your nearest Gulf office and have a Gulf Sales Engineer recommend the most suitable type for every job.

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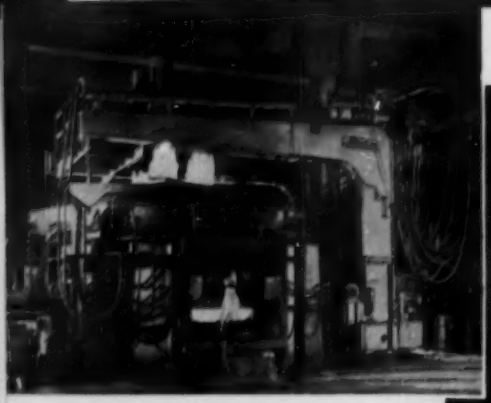
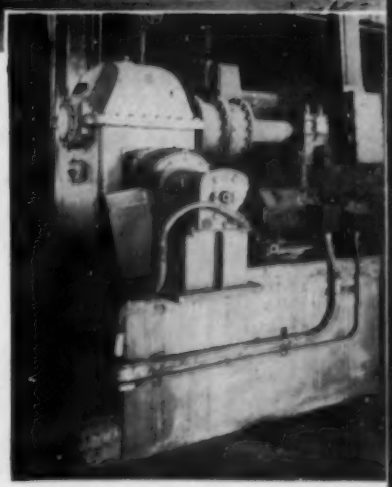


Shown above is a 20′ diameter shell Top-Charge Heroult Furnace. At right, the same furnace is shown with swing-type roof removed for charging. Smaller picture at lower right, shows tilting mechanism for 20′ diameter Heroult.



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THIS CATALOG

contains up-to-date information on Heroult Electric Furnaces — types, sizes, capacities, rating, etc. For free copy, write to our Pittsburgh office.

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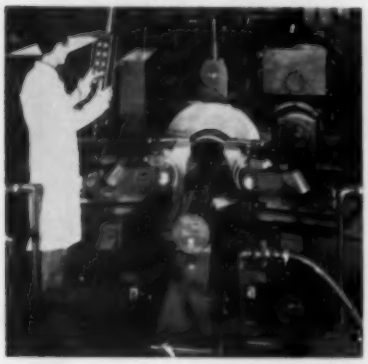
Engineering Digest of New Products . . .

Spinning Machine

A new, heavy duty machine for cold spinning cones and tubes, has been introduced by the Process Machinery Division of the Cincinnati Milling Machine Co. The standard machine is built in a 42 x 50-in. size, in both plain and duplex models. It has the capacity to cold spin regular contoured hollow cones and tubes up to 42 in. in diameter by 50 in. long. Roll force, which



may result in unit pressure as high as 400,000 psi, is sufficient to roll a ¾-in. flat disk of A.I.S.I. 4130 steel down to a 60-deg. included angle straight-wall cone in one pass. Parts may be spun from flat disks, preformed blanks or rings of virtually any ductile metal. The machine consists of a heavy, welded steel bed which rigidly supports the headstock, tailstock and the main slide units. Tee slots in the bed permit universal positioning of the main slides which support the roller carriers. The hydraulically powered roller carriers are independently controlled and may be traversed simultaneously or individually, depending upon the spinning operation.

For further information circle No. 271 on literature request card, p. 32-B

Titanium Alloy

A 6A1-4V titanium alloy has been announced by Mallory-Sharon Titanium Corp. The new alloy does not become embrittled at elevated temperatures, and can be used up to 750° F. with minimum creep or change of properties. It has good strength and stability at high temperatures, is relatively insensitive to notches, and can be hot worked over a wide range. Composition is 5.5 to 6.5% Al, 3.5 to 4.5% V, 0.1% max. C, 0.03% max. Ni, 0.2% max. O, other elements 0.6% max, and the remainder titanium.

For further information circle No. 272 on literature request card, p. 32-B

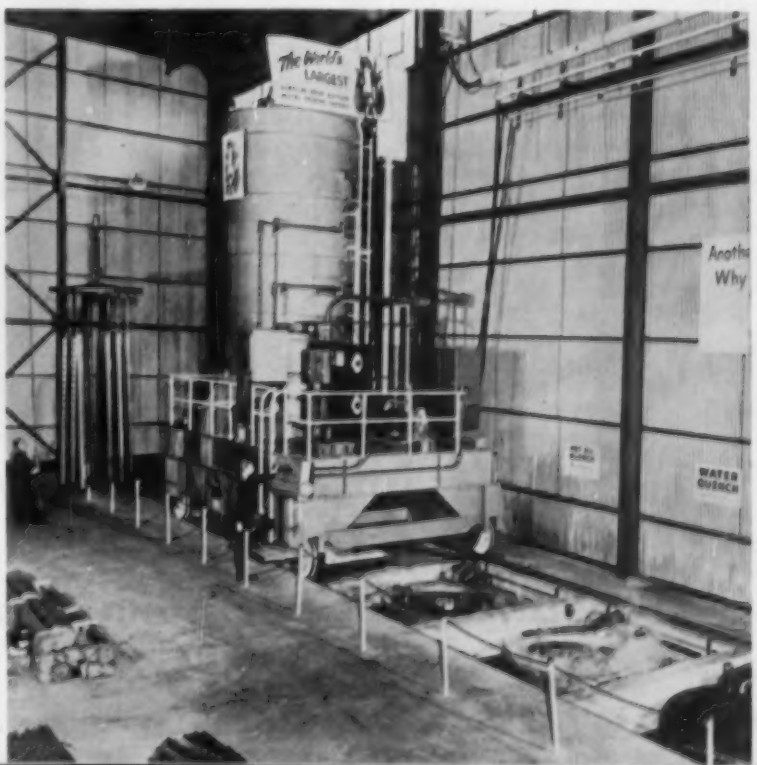
High Frequency Generators

A new line of high frequency generators for induction and dielectric heating has been announced by New Rochelle Tool Corp. All cubicles are only 36 in. wide and may be fully opened on two or three sides for servicing. Motor generators are used to generate frequencies to 9600 cycles per sec. and vacuum tubes for 450 kc. to 40 mc. Water cooled motor generators, tubes and high voltage filled transformers are used wherever feasible to insure adequate cooling and freedom from failure under adverse atmospheric conditions. Heavy pressed steel frames, shock mounted components, and unbreakable water columns reduce the danger from damage

Heat Treating Furnace

A large drop-bottom, metal treating furnace, designed by Loftus Engineering Corp., has been announced by Metallurgical, Inc. Built for vertically heat treating extra long parts, the furnace hardens, anneals, stress relieves and normalizes steel and aluminum. The furnace is mounted on a carriage and moves along tracks over a pit, 25 ft. deep and 60 ft. long. The pit houses three agitator-type quench tanks permitting quenching in water, martempering oil or hot salt. The water and oil tanks have a capacity of 6300 gal. each, while the hot salt tank is charged with 105,000 lb. of molten salt. The distance from the bottom of the pit to the top of the furnace is 55 ft. Parts to be hardened are suspended from a fixture in the loading end of the pit, hoisted into the furnace through the bottom, and brought up to the specified temperature for the required time. The operator then moves the furnace over the desired quench and lowers the load at a speed of from 1 to 10 ft. per sec.

For further information circle No. 273 on literature request card, p. 32-B



The metal spars that support the rotor blades of the famed Piasecki "workhorse" are the modern version of masts on clipper ships . . . must stand great stress and strain.

To heat treat the Piasecki spars, the Metlab Company of Philadelphia uses a specially designed furnace, unusual techniques . . . and . . . Sun Quenching Oil Light.

For strength and flexibility . . .

20′ Piasecki Rotor Spars Quenched In Sun Quenching Oil Light

It takes real know-how to heat treat the 20 ft long tapered tubing used in Piasecki spars. At the Metlab Company of Philadelphia, Sun Quenching Oil Light plays a major role in the success of this job.

Sun Quenching Oil Light was originally selected by Metlab Company, after lengthy tests, because of its all around quenching ability, low cost and long life. For the Piasecki job, Sun Quenching Oil Light helps give the spars exactly the qualities they need . . . maximum strength with a minimum of distortion. *Proof once more of the ability of Sun Quenching Oil Light to satisfactorily perform difficult oil quench jobs.*

For information about how Sun Quenching Oil Light can perform for you . . . whether in a job shop or on a production line . . . see your Sun representative or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-8.

SUNOCO

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY PHILADELPHIA 3, PA.

IN CANADA: SUN OIL COMPANY LTD., TORONTO AND MONTREAL

due to shock vibration and abuse of an accidental nature.

For further information circle No. 274 on literature request card, p. 32-B

Hardness Tester

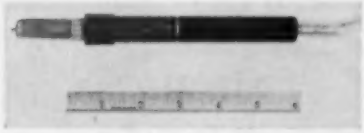
Ferrous metals in regular and irregular shapes can be tested for hardness at the bench or almost anywhere in the plant, storage rack or at the machine with the portable Brinell hardness tester recently announced by Andrew King. Accuracy of the precision unit is within A.S.T.M. require-

ments and it can be used in any position, even upside down. It puts a load of 3000 kg. on a 10-mm. ball with intermediate loads as required. It can be used near power hammers or other places where there is vibration without affecting accuracy of tests. The removable test head makes it possible to test parts of any size.

For further information circle No. 275 on literature request card, p. 32-B

Welding Torch

A new heliarc pencil torch for inert gas shielded, arc welding of light metals has been announced by Linde Air Products Co. Its 180-deg. head is designed for working in tight places that are hard to reach with torches of



standard head angle. It is air-cooled and has a 110-amp. continuous-duty current capacity. It will join mild steel and hard-to-weld metals like aluminum, magnesium, stainless steel, Monel, Everdur, copper, brass, and high-alloy steels. The Pencil HW-9 is light and small for easy handling and manipulation. Without cable, the 7-in. torch weighs 3 oz. and has a maximum diameter of ⅝ in.

For further information circle No. 276 on literature request card, p. 32-B

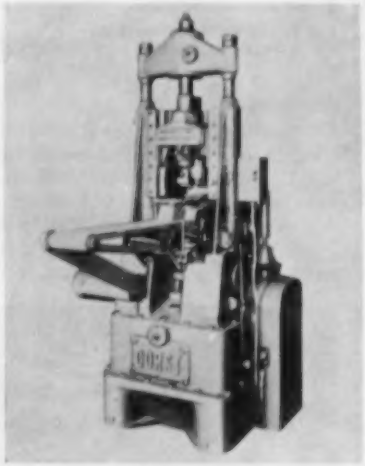
Cermet

Metal Hydrides, Inc., has announced the availability of nickel-magnesium oxide cermet which resists oxidation and erosion at elevated temperatures. The new cermet is a powder of −100 mesh, and can be flame-sprayed or brushed on surfaces of mild steel, stainless steel, and other alloys. The coating can be built up to 0.0030 in. It is applicable to retorts, furnace surfaces, and other steels and alloys subjected to oxidation and erosion at high temperatures.

For further information circle No. 277 on literature request card, p. 32-B

Powdered Metals Press

Arnhold Ceramics, Inc., has announced a new fully automatic Dorst press for compacting powdered metal. Important features of the new press include smooth toggle motion with fast approach to die cavity and slow final entry into die. A special device permits adjustable timing of the floating die in relation to top punch, which pro-



motes uniform density throughout. Hydraulic cushion combined with clear visibility pressure gage and electrical cut-out switch disengages clutch in case of overpressing. Pick up mechanism lifts the pieces out of die cavity and transfers them onto a conveyor belt which is synchronized with speed of machine.

For further information circle No. 278 on literature request card, p. 32-B

Titanium Alloy

Clevite Corp. has announced a titanium alloy with a tensile strength of 65,000 to 85,000 psi. Small additions of

SERV-RITE

Insulated Thermocouple Wire Extension Lead Wire

FOR

PLATINUM COUPLES
CHROMEL ALUMEL
IRON CONSTANTAN
COPPER CONSTANTAN
IRON CUPRONEL

No matter what your wire or insulation requirements may be, you can depend on Gordon "Serv-Rite" insulated wire for pyrometers—recognized as a standard of highest quality for nearly half a century. All "Serv-Rite" wire is now manufactured in the new, completely modern Gordon plant, employing up-to-date equipment and machinery, supervised and operated by skilled technicians—your guarantee of continued precision quality. In addition to maintaining large stocks of all common types of wire, Gordon will manufacture special insulation, in long or short runs, to suit your individual needs and meet your most rigid specifications.

All Types of Insulation

Felted Asbestos
Asbestos Braid
Weatherproof Braid
Glass Braid
Polyvinyl Plastic
Nylon Braid
Stainless Steel Armored Braid
Silicone Treated
Cotton Braid
Lead Jacket

Ask for Bulletin No. 1200 for Application Data and Complete Specifications on Thermocouple and Extension Wire

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Precise
TEMPERATURE MEASUREMENT

Is one of the many applications of the
TYPE B HIGH PRECISION POTENTIOMETER

...a general purpose potentiometer with a number of notable refinements, suiting it particularly to thermocouple work. Distinctive features include:

- Three ranges —0 to 16 millivolts, 0 to 160 millivolts and 0 to 1.6 volts.
- Three reading dials—effective scale length of approximately 175 feet for each range.
- Subpanel switch and slidewire construction for protection of contacts from dust and corrosive fumes.
- Special provisions to minimize parasitic thermal emf's—including automatic compensation of slidewire thermals and gold contacts in galvanometer key.
- Exceptional convenience in reading and adjustment.
- Solid and substantial construction for many years of trouble-free service.

This standard laboratory potentiometer is also well suited for meter calibration, for checking portable potentiometers, and for other critical measurements of D.C. potentials requiring exceptionally high accuracy.

Described in Bulletin 270

SPOTLIGHT GALVANOMETER FOR SHOP AND LABORATORY WORK

- Sturdy, short period
- Sensitive (up to 1.5 μV per mm.)
- Multiple-reflection optical system
- 100-Millimeter scale
- For null or deflection measurements

Described in Bulletin 320

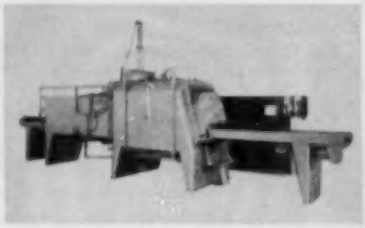
RUBICON COMPANY
Electrical Instrument Makers
3758 Ridge Avenue • Philadelphia 32, Pa.

aluminum replace other interstitial elements, such as oxygen, as a strengthener. The alloy is a powder metal product. Its impact strength is 40 to 50 ft. lb. at room temperature, and its notched fatigue endurance ratio in the range of 28 to 32% at 10,000,000 cycles.

For further information circle No. 279 on literature request card, p. 32-B

Controlled Atmosphere Cooling

Ipsen Industries, Inc., has announced three new heat treating units featuring multiple cooling zones for air-cooling of work under protective

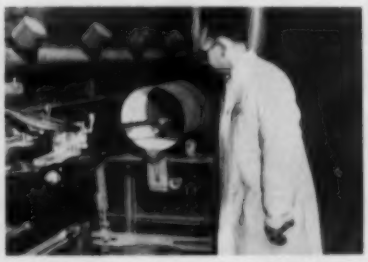


atmospheres. The units are classified at 400, 500, and 900 lb. per hr. at 1500° F. Maximum weight per charge is 600, 800, and 1400 lb. respectively. Operating temperatures of 1850 or 2150° F are available.

For further information circle No. 280 on literature request card, p. 32-B

Refractory Coatings

A new line of pure oxide refractory coatings has been announced by Norton Co. Rokide pure oxide coatings have been tested in a wide range of field applications for protecting metals from the effects of high temperatures and corrosion. These coatings are of



Applying Aluminum Oxide Coating to Inside Surface of Ramjet Part

two types; aluminum oxide coatings on metals, and silicon carbide on graphite base materials. Aluminum oxide coatings are applied in a molten state by means of a metallizing-type spray gun. Thickness of coating is usually between 0.005 and 0.050 in. although coatings of 0.100 in. thick have been successfully applied. It is very hard, has good wear and chemical

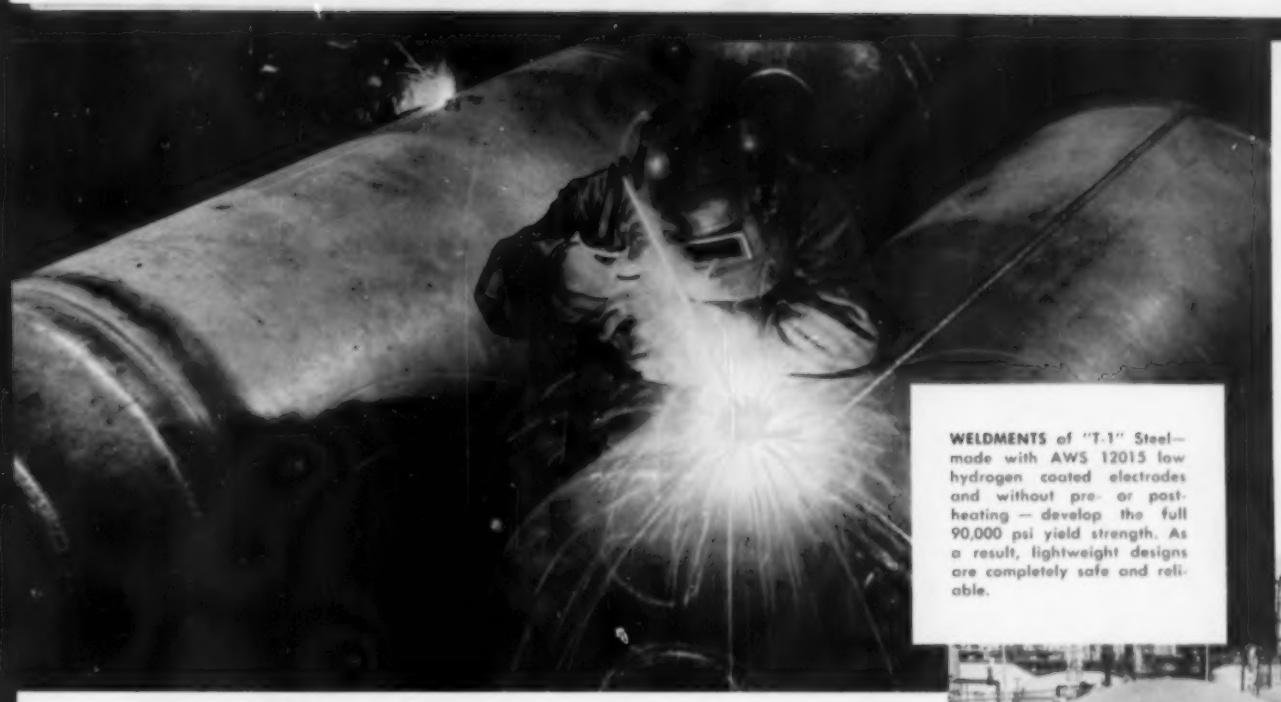
Do You Know the Answer to Oven Questions Like These?

- **What is the average specific heat of aluminum, copper, magnesium?**
- **How do you measure heat energy in relation to your product?**

Questions like these and literally dozens of others are answered in this new Oven FACT BOOK by MOCO. Written in "easy-to-read" language, you'll find yourself referring to it time-after-time for heat processing information. And it's yours—FREE for the asking. Write today—on your letterhead, please.

Brought to you by the Michigan Oven Company—manufacturers of *ovens* and only *ovens*.

MICHIGAN OVEN COMPANY
417 BRAINARD
DETROIT 1, MICHIGAN



WELDMENTS of "T-1" Steel—made with AWS 12015 low hydrogen coated electrodes and without pre- or post-heating — develop the full 90,000 psi yield strength. As a result, lightweight designs are completely safe and reliable.

NEW USS "T-1" STEEL has great potential for reducing cost of pressure vessels

You've heard of Operation "T-1." You've heard how those dramatic tests proved that, when and if higher design stresses are permitted, USS "T-1" constructional alloy plate steel will make possible larger, stronger pressure vessels, vessels that can be built more easily and at lower over-all cost. As a result of Operation "T-1," several major pressure vessel fabricators have requested approval from the ASME to use USS "T-1" Steel in unfired pressure vessels. Why? For mighty good reasons:

"T-1" Steel has a very high yield strength – 90,000 psi minimum – three times that of conventional plate steels now used in pressure vessels. Yet it is extremely *tough* and can withstand high stresses and pressures even at temperatures far below zero. What's more, USS "T-1" Steel remains strong at *high* temperatures up as high as 900 degrees F.

Yet, "T-1" Steel is easy to fabricate. It can be drilled, machined, or cold formed, and welded or flame-cut *without* pre- or post-heating. **"T-1" can make pressure vessels . . .**

LARGER. For a given pressure and shell thickness, the *radius* of a vessel may be increased in direct proportion to the ratio of working stresses. Result: more storage capacity at lower cost.

STRONGER. For a given radius and shell thickness, the *pressure* may be increased in proportion to the ratio of working stresses. Result: vessels for higher pressures at lower cost.

LIGHTER, EASIER TO BUILD. For a given pressure and radius, the shell thicknesses may be reduced, thus permitting larger vessels to be fabricated *without stress relief*. Result: lower fabrication cost.

United States Steel, Room 4799
525 William Penn Place, Pittsburgh 30, Pa.

☐ Please send me your booklet "United States Steel presents T-1" which contains the full story of "T-1" steel.

☐ Have your representative get in touch with me.

Name .....

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UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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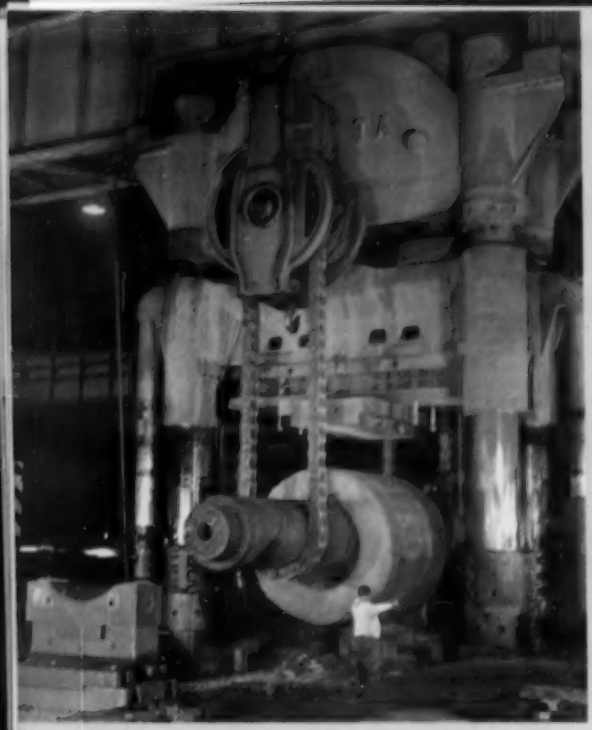
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

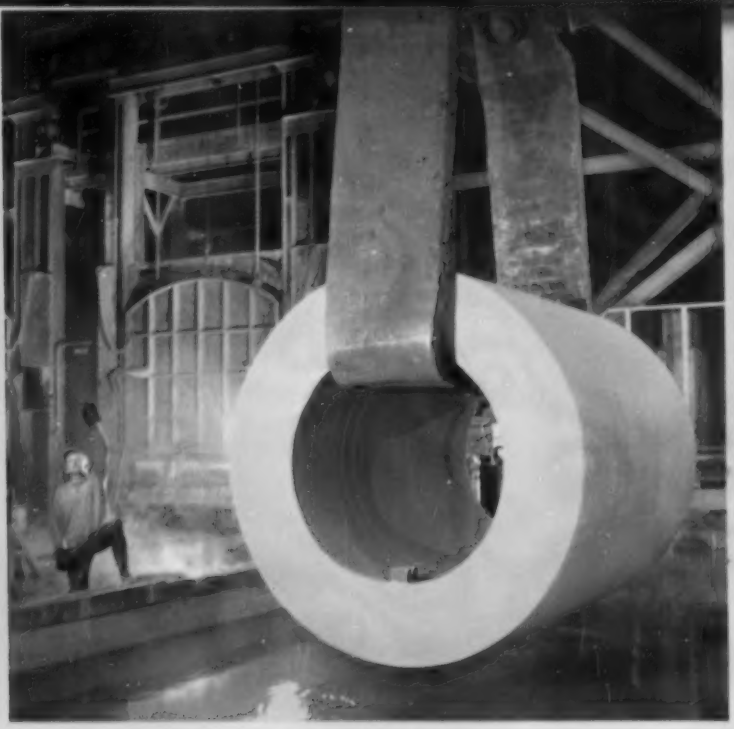
SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

USS

UNITED STATES STEEL



Here, one of the cylinders is being forged on the 7,000-ton press. Masterful work on the mandrel and precision manipulation of the press provide proper thickness/diameter ratio.



The cylinder (largest of its kind ever forged) is about to be lowered into the water quench tank after heat treating.

GE gets ready to make some big crashes

General Electric's Large Steam Turbine-Generator Department recently installed a high-speed burst pit to investigate the bursting characteristics of wheels and rotors. Model forged turbine and generator shafts and other partial and full scale parts will be spun at speeds up to 25,000 rpm or until they burst.

The big burst pit includes two concentric forged steel cylinders, made by the Homestead Forgings Division of U. S. Steel. These 60-ton cylinders must possess a strength that almost defies description because tremendous forces are at work here.

Imagine 200 automobiles traveling 100 mph crashing simultaneously. These U. S. Steel Quality Forgings have been designed to absorb that same amount of energy (200 *million* foot pounds).

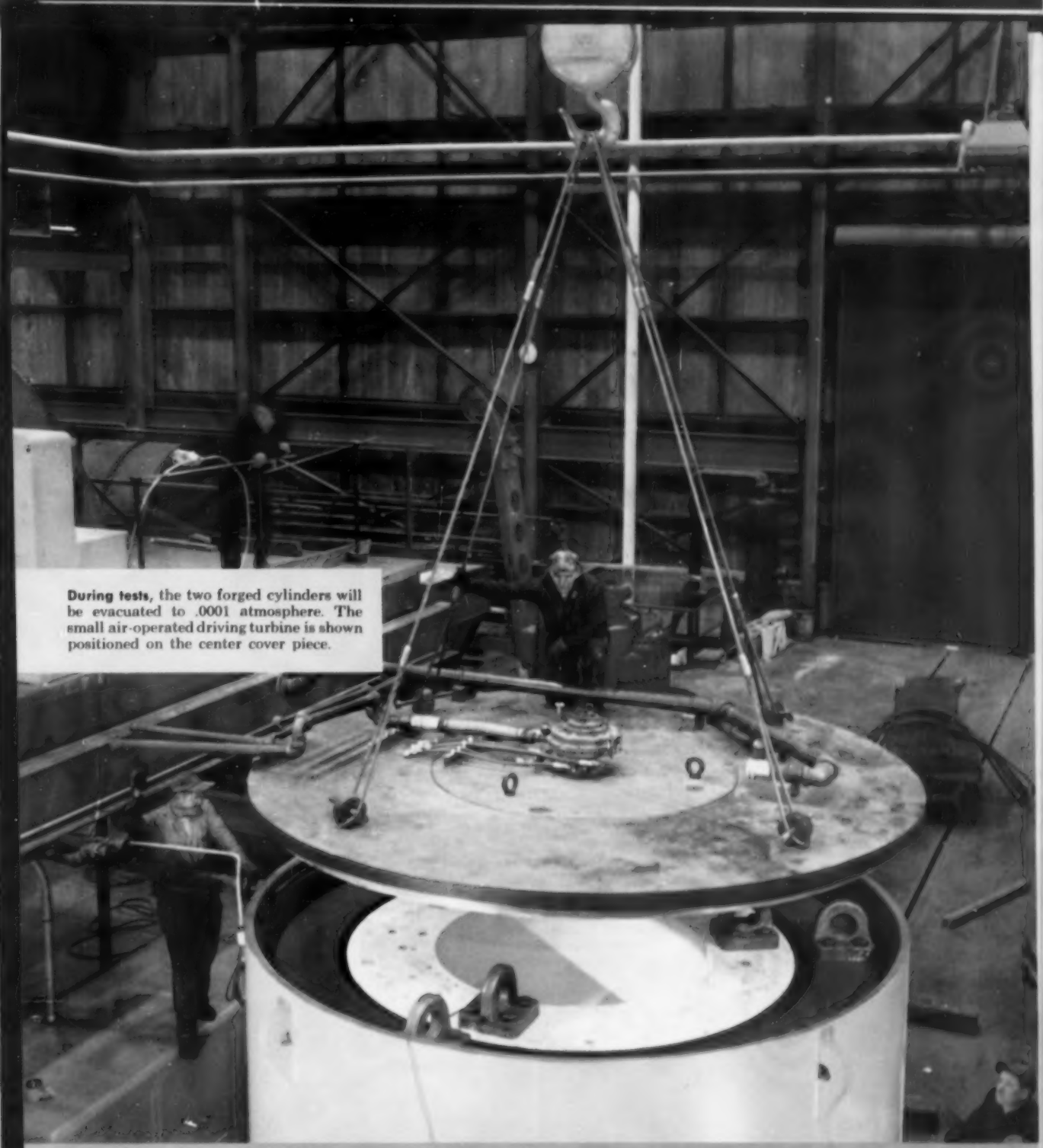
With this testing facility, General Electric engineers expect to learn new things about material strength and rotor design which will permit building ever-better turbine-generator units to keep up with the demand for low-cost electric power.

U. S. Steel's Homestead Forgings Division produces a complete range of high-quality forgings, including turbine-generator shafts, heavy machinery parts, and giant sleeves like GE is using in this burst pit. We solicit your inquiries or requests for our free booklet on USS Quality Forgings. Just write to United States Steel, 525 William Penn Place, Room 4799, Pittsburgh 30, Pa.

SEE **The United States Steel Hour.** It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

UNITED STATES STEEL

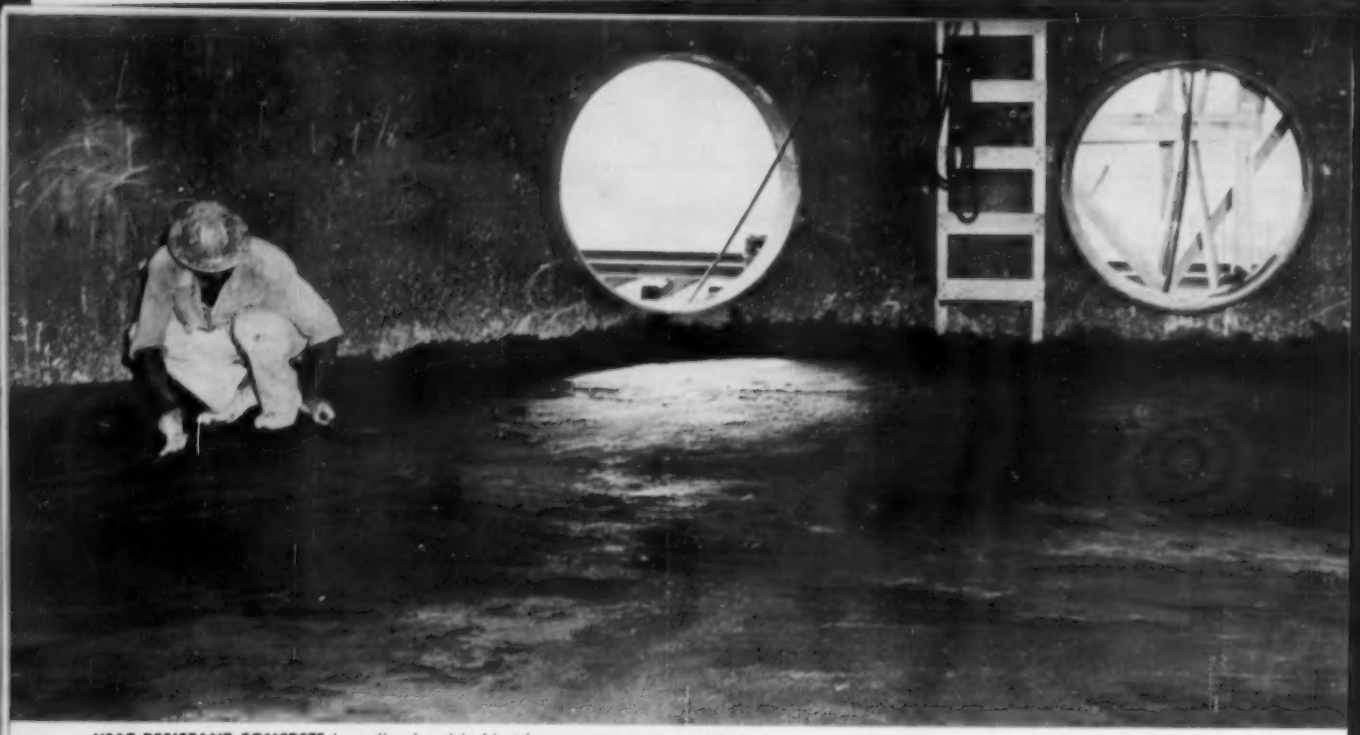


During tests, the two forged cylinders will be evacuated to .0001 atmosphere. The small air-operated driving turbine is shown positioned on the center cover piece.

USS

Quality FORGINGS

- heavy machinery parts—carbon, alloy, stainless
- forged steel rolls and back-up roll sleeves
- electrical and water wheel shafts
- hammer bases and columns



HEAT-RESISTANT CONCRETE is easily placed in blast-furnace stove pads at U.S. Steel Corporation's Fairless Works, Morrisville, Pa. Industrial Concrete made with Atlas Lumnite cement speeds placement . . . reaches service strength within 24 hours!

Blast-furnace stove pads are easy to place with heat-resistant concrete

BLAST-FURNACE STOVES are only one example of the many ways that Industrial Concrete serves the metal industry. Industrial Concrete made with Atlas Lumnite cement gives long, trouble-free service . . . needs less maintenance.

Quickly placed for long, trouble-free service, blast-furnace stove pads are only one of the many ways that Industrial Concrete made with Lumnite* calcium-aluminate cement saves time and cuts costs in metal-industry plants.

Industrial Concrete is easy to make with Lumnite cement and suitable aggregates. It helps speed construction and repair work because it can be poured, troweled, or "shot" in place . . . reaches service strength in less than 24 hours! You get all the placement convenience and structural advantages of concrete with four important extras — high-temperature service (up to 2600°F.), corrosion resistance, wear resistance, and *insulation*.

For added convenience you can use a Lumnite-base castable — packaged mixes of Lumnite cement plus aggregates selected for specific temperature and insulation needs. All *you* do is add water, mix and place. Castables are made and distributed by leading manufacturers of refractories.

You'll find Industrial Concrete made with Atlas Lumnite cement excellent for use wherever heat, corrosion or abrasion are problems. For more information, write Lumnite Bureau, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

OFFICES: *Albany, Birmingham, Boston, Chicago, Dayton, Kansas City, Minneapolis, New York, Philadelphia, Pittsburgh, St. Louis, Waco.*

"LUMNITE" is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

MM-L-108

ATLAS® **LUMNITE for INDUSTRIAL CONCRETES**

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

A UNIVERSAL ATLAS PRODUCT

UNITED STATES STEEL HOUR—Televised alternate weeks—See your newspaper for time and station.

More and more buyers, designers and production men are learning that Seymour's new, up-to-the-minute production machinery and three quarter century of experience assures them of top quality Nickel Silver with . . .

- **UNIFORMITY OF GAUGE** for the full width and length of the metal.
- **MAINTENANCE OF CLOSER TOLERANCES** which is made possible by the use of modern, precision rolling equipment.

These pace-setting standards are rapidly raising Seymour-quality Nickel Silver to the top of the "Preferred" List for hundreds of executives who specify and buy primary metals.

Equally famous for their exceptional quality are Seymour BRASS • PHOSPHOR BRONZE • WELDING ROD • BRIGHT (Plating) NICKEL • NICKEL ANODES

SEYMOUR

THE SEYMOUR MANUFACTURING COMPANY — SEYMOUR, CONNECTICUT

Three NEW Refractory Products For Reaction Motors

IN THIS "high temperature age," when industry is asking for materials with ever higher melting points, the requirements of reaction motors are extremely demanding.

Depending upon extreme temperature differentials in converting heat into useful work, the power plants for jet propulsion present unique time-vs.-temperature problems. To meet these problems, component materials must be able to withstand not only very high temperatures but also other factors such as thermal shock, erosion, corrosion and oxidation.

Aware of these requirements, Norton Company has for years been engaged in a program of experimentation, development and testing of various materials. A number of these have proved highly satisfactory for reaction motor and similar applications; in particular, the three described below.

ROKIDE* "A" Aluminum Oxide Coating

A hard, adherent, refractory oxide coating, pure white in color and containing about 98.6% Al_2O_3. It has been successfully applied on ceramics, glass, and certain plastics but particularly on metals in thicknesses of .005" to .050", and greater in special cases. This crystalline oxide coating protects the base material under high temperatures and erosion conditions, and its alumina, being harder than the hardest steel, provides strong resistance to abrasion. ROKIDE "A" coating is thermally and electrically insulating and is slightly permeable. This coating and coating process are covered by U. S. Pat. #2,707,691.

ROKIDE "C" Silicon Carbide Coating

This coating was developed to improve graphite components for high temperature use. It consists of a protective layer of pure CRYSTOLON® silicon carbide, of dark gray or gray-green color, formed at high temperature on the graphite, to protect it and increase its resistance to erosion and oxidation. The coating varies between .002" and .030" but is usually around .010". It reacts integrally with, and becomes a part of, the graphite surface. A considerable part of the coating, therefore, is chemically derived from the graphite itself. ROKIDE "C" coating has excellent thermal shock resistance and extreme resistance to abrasion. It is slightly permeable. This coating process is covered by U. S. Pat. #2,667,627.

CRYSTOLON® "N" Silicon Carbide Products

These are monolithic bodies, kiln-fired at high temperature and molded to close dimensions in a wide variety of shapes and sizes. They have greater resistance to mechanical and thermal shock than most ceramics and, compared to other commercial refractory products, are very strong. CRYSTOLON "N" material is dense and extremely refractory. Products made of it have been used successfully at estimated temperatures as high as 5000°F for varying periods of time.

Applications

Typical applications for which these products have shown exceptional promise:

Rockets: nozzles, motor tube linings, thermal barriers.

Guided Missiles: vanes, skin protection, motor components.

Ram Jets: tail pipe lining.

Gas Turbines: inner combustion chamber lining, cross fire tube lining, flap nozzle coating, housing and shroud ring insulation.

Miscellaneous: burner parts protection, electrical insulation, thermocouple tube protection.

Licensing Policy

A license for the use of the ROKIDE "A" aluminum oxide coating process can be obtained from Norton Company.

Other Norton Products

of interest to designers and builders of reaction motors include refractory ceramic materials of commercial type, including fused stabilized zirconia, various CRYSTOLON products, MAGNORITE® fused magnesium oxide products and ALUNDUM® fused aluminum oxide products. Norton also makes a number of refractory carbides, borides and nitrides. These high-melting materials, which have varied applications in many fields, are also the basic ingredients of the famous Norton Refractory Rx's — refractories *engineered and prescribed* for the widest range of uses.

For further information on Norton products for reaction motors — or for other applications — write, mentioning your requirements, to NORTON COMPANY, 329 New Bond Street, Worcester 6, Mass.

In Rockets, Jet Planes and Guided Missiles, Norton products for reaction motors — ROKIDE "A" Aluminum Oxide Coating, ROKIDE "C" Silicon Carbide Coating and CRYSTOLON "N" Silicon Carbide Monolithic Bodies — are used for many applications.

NORTON

REFRACTORIES

Engineered... Rx... Prescribed

Making better products... to make your products better

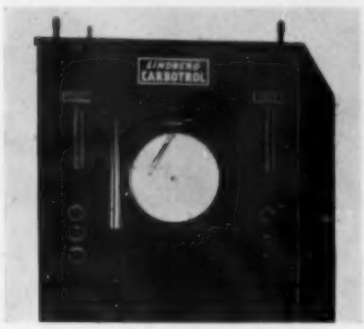
*Trade-Mark

resistance qualities, is a nonconductor of electricity, and weighs about half as much as steel. Silicon carbide coatings have been applied successfully only on graphite shapes up to the present time. A thin coating of silicon carbide provides the needed high temperature and erosion protection.

For further information circle No. 281 on literature request card, p. 32-B

Dew Point Controller

A new automatic controlling, recording, and proportioning instrument which enables the heat treater to set his atmosphere generator or furnace in equilibrium with the steel to be heat treated has been announced by Lindberg Engineering Co. The heat treater sets the pointer on the control instrument for the carbon content of the steel he wishes to treat and the Carbo-



trol will automatically control the atmosphere generator to produce a protective atmosphere in equilibrium with the steel. The Carbotrol automatically corrects the air-gas ratio of the generator to produce a constant dew point, or carbon potential, as the raw gas supply and pressure vary. Range of control is 0.30 to 1.5% carbon potential and +70 to −5° F. dew point. Endothermic generator gases are used.

For further information circle No. 282 on literature request card, p. 32-B

Inconel Fixtures

An Inconel tray for both annealing and pickling of 105-mm. steel cartridge and shell cases has been announced by Wiretex Mfg. Co. The shell cases are draw annealed at tem-

peratures of 1100 to 1200° F., in either batch or continuous furnaces. They are annealed, quenched, pickled and washed in the same tray. The sides of the tray are fabricated of ⅛ in. sheet and the bottom grid is made of ⅛ by 1 in. bar stock pressed and welded together. The top frame and side braces are of ½-in. rod.

For further information circle No. 283 on literature request card, p. 32-B

Hardness Tester

Availability of the Mark VI Penetrascope metal hardness tester has been announced by the Tinius Olsen Testing Machine Co. It is used for testing ferrous as well as nonferrous metals of various sizes, shapes and contours from metal strips only 0.002-in. thick to cylinders over 8 ft. in diameter. Testing in the 16 to 800/1000 DPH range and up to 1500 DPH (Rockwell C75) is possible. The Penetrascope can be transported and fastened directly to parts of any size, wherever desired.

For further information circle No. 284 on literature request card, p. 32-B

Flux

Alpha Metals, Inc., has announced a general purpose soft soldering flux kit containing a complete set of 16 fluxes, including printed circuit, electronic and general purpose fluxes. It enables a rapid determination of the proper flux for a soldering job and saves the

trouble and time involved in acquiring samples. Each flux is contained in labeled glass bottles. The flap of the carton has a chart showing each flux in its position in the carton.

For further information circle No. 285 on literature request card, p. 32-B

Aluminum Alloy for Electrical Industry

New high-strength aluminum alloy, to serve the needs of the electrical industry has been announced by Revere Copper and Brass, Inc. The develop-

keeping up with

SODIUM

Titanium, first produced by a sodium reaction way back in 1910, has been commercialized only within the last five years. Its properties of high strength-weight ratio and corrosion resistance are important reasons for the growing demand in military and industrial uses. Carbide & Carbon and I.C.I. – the two newest producers – are using sodium routes. U.S.I.'s versatile metal offers cheaper, safer, easier processing than the original magnesium method of commercial manufacture.

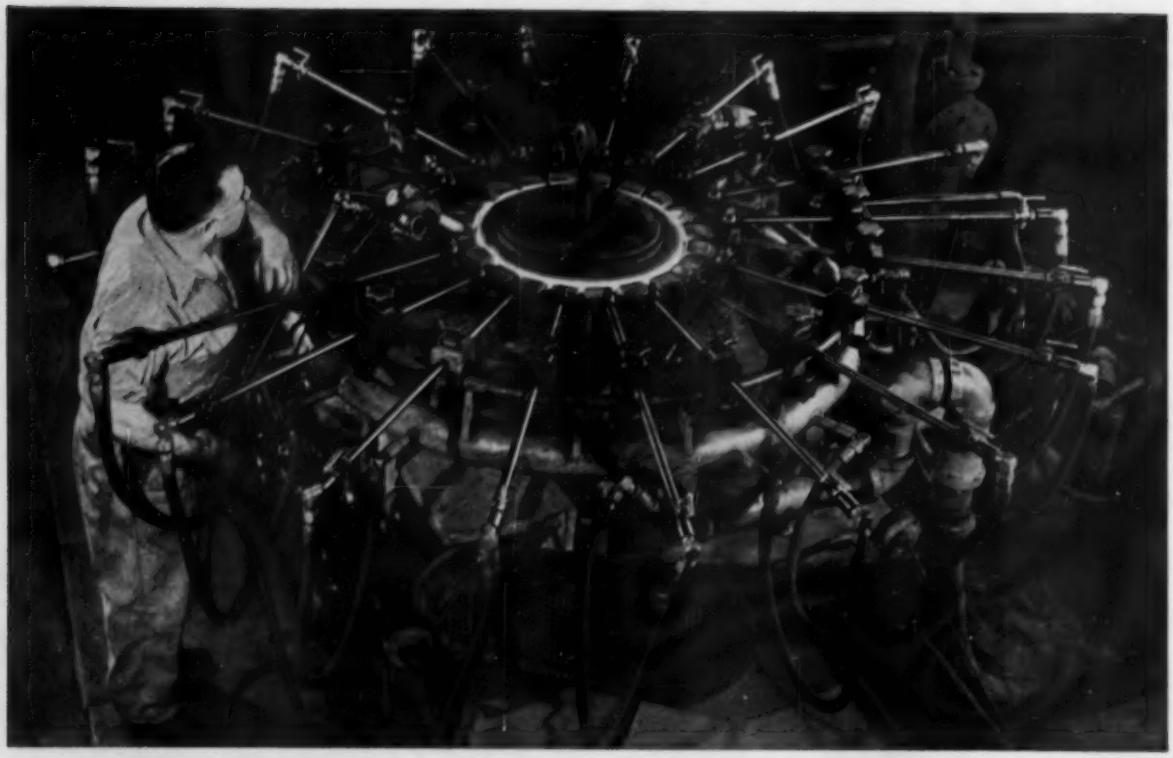
NONE OF THE OLD OIL

Contrary to a common impression, commercial sodium *is not* handled, stored or shipped under oil. U.S.I. ships sodium metal as dry bricks, in steel drums, and cast solid in drums and tank cars. Sodium bricks are handled safely in air. In fact, bricks are molded in the open because sodium does not burn below 120°C–(M.P.97.5°C).

U.S.I.

USE OUR EXPERIENCE – SEE U.S.I. FOR HELP ON YOUR SODIUM REACTIONS

INDUSTRIAL CHEMICALS CO.
Division of National Distillers Products Corporation
99 Park Avenue, New York 16, N. Y.
Branches in principal cities



Flame hardening set-up shows an application of Selas "Superheat" burners at the Wiedermann Machine Co., Philadelphia. With burners grouped like this, high temperature effects are intense. In this service, Inconel jackets give 5 times the life of any other alloy tried.

Sheathed with Inconel

these "Superheat" Burners last 5 times longer

"Inconel shells mean big savings for our customers," Selas says

These "vest-pocket" Selas furnaces blast out heat at rates on the order of 2000 feet per second . . . 40,000,000 BTU/ft³. Jet action is so strong, work pieces are sometimes heated, formed, and delivered by thermal impact alone.

Metal burner shells used to burn out fast. In one severe application, jackets averaged only 100 hours. Now, Inconel sheathing gives a minimum of 500 hours.

"In this operation (surface hardening)," says Selas, "Inconel shells cut costs approximately 70%."

What's hot in your shop?

Whatever it may be, chances are, Inconel can handle it. Here are three reasons why:

1. Inconel stays usefully strong up to 2100°F., resists thermal shock.
2. Inconel resists oxidation, hydrogen embrittlement, many other types of corrosion.
3. Inconel is easy to form, machine, weld . . . available in all commercial forms.

A new Inco booklet, "Keep operating costs down, when temperatures go up" suggests many ways to use Inconel and other Inco heat resisting alloys effectively. Dozens of types of equipment shown. Write for a copy.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

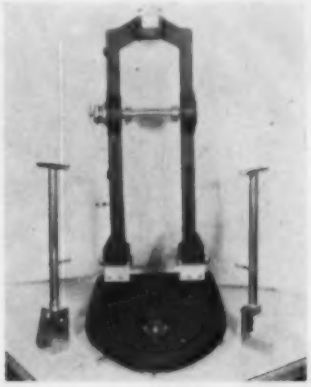
Inconel . . . *for long life at high temperature*

ment was a joint project with the Aluminum Co. of Canada. Revere 6263 is available in either the T6 or T8 temper. Tensile strength is 29,000 psi. and yield strength 25,000 psi.; electrical conductivity of the T6 grade is 55 and of the T8 grade, 57, as compared with copper. The alloy contains 0.40% (max.) iron, 0.30 to 0.60% silicon, 0.40 to 0.80% magnesium, and the remainder aluminum.

For further information circle No. 286 on literature request card, p. 32-B

Impact Tests

Impact test results in a capacity range of 1 ft.lb. have been announced by Baldwin - Lima - Hamilton Corp. Either Izod or Charpy tests can be made with 1 ft.lb. pendulum assemblies, as well as with other assemblies

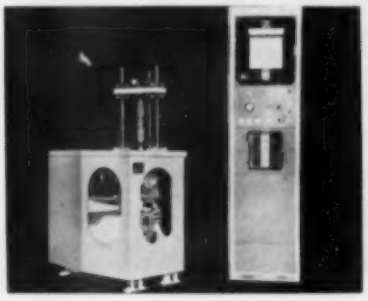


of 2, 4, 8 and 16 ft.lb. capacities. Pendulum assemblies are attached to the horizontal bearing shaft by a pair of sliding collars held in place by set screws around an integral pendulum member in the form of a longitudinally cut segment of tubing that fits into a matching recess in the shaft.

For further information circle No. 287 on literature request card, p. 32-B

Creep Testing

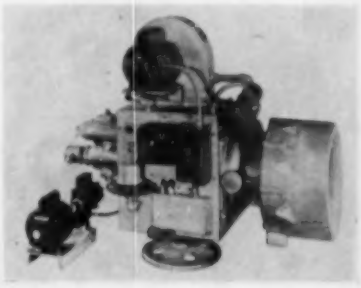
A machine for dynamic testing of metals for creep and fatigue at ambient and elevated temperatures has been announced by the Ivy Co. A static force of 0 to +5000 lb. and an alternating force of 0 to ±4000 lb. at 3600 c.p.m. with a maximum amplitude of 0.050 in. may be applied. Creep up to 0.375 in. can be accommodated. A separate cabinet houses all controls and controllers for the basic machine and the high-temperature unit, and also the recording instruments.



For further information circle No. 288 on literature request card, p. 32-B

Gas-Oil Burner

A new fan-type combination gas-oil burner for firing rates up to 3,000,000 Btu. has been announced by the Eclipse Fuel Engineering Co. The unit



includes blower, burner, oil pump with motor, built-in tuyere, air-gas mixer, safety equipment, transformer, valves, regulators, filter, piping and wiring. It can be used with gas and light oil, oil or gas for automatic off-on firing.

For further information circle No. 289 on literature request card, p. 32-B

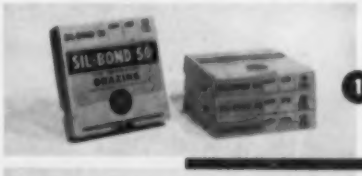
Voltage Controller

A new midget voltage controller, 4 x 4 x 4 in., has been announced by Fisher Scientific Co. The instrument to be regulated is plugged into the outlet in the rear of this small variable transformer; the controller is then connected to the power line. It is rated at 1.25 amp. and is adjustable from 0 to 120 volts when the input is 115-volt, 50/60 cycle a-c.

For further information circle No. 290 on literature request card, p. 32-B

United's SIL-BOND

Makes Low Temperature Brazing Easier 3 BIG WAYS



1 IDENTIFICATION FOR INVENTORY CONTROL
Easier to identify for alloy, size, exact weights and laboratory inspection number. Packaged for protection against dirt, oxidation and other contamination.

2 CLEANEST COILS MADE
Compare SIL-BOND coils with any other brand for purity, cleanliness and uniformity of temper . . . comparison is SIL-BOND's best salesman!

3 EASIER TO UNWIND
SIL-BOND is better drawn, tighter coiled . . . so it unwinds easier, saves costly preparation time! Important in hand fed brazing . . . vital in automatic brazing!

SIL-BOND — The Dependable Low Cost, Low Temperature Brazing Alloy!
Better Because It's Made Better and Packaged Better!
Dependable United Product Analysis Makes The Brazing Difference!

ALWAYS Braze with SIL-BOND or PHOSON!
Ask for SIL-BOND Booklet NOW!

Ask to see the new United Wire color film "When Metals are Brazed". Write for showing dates and literature.

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PROVIDENCE 7, RHODE ISLAND
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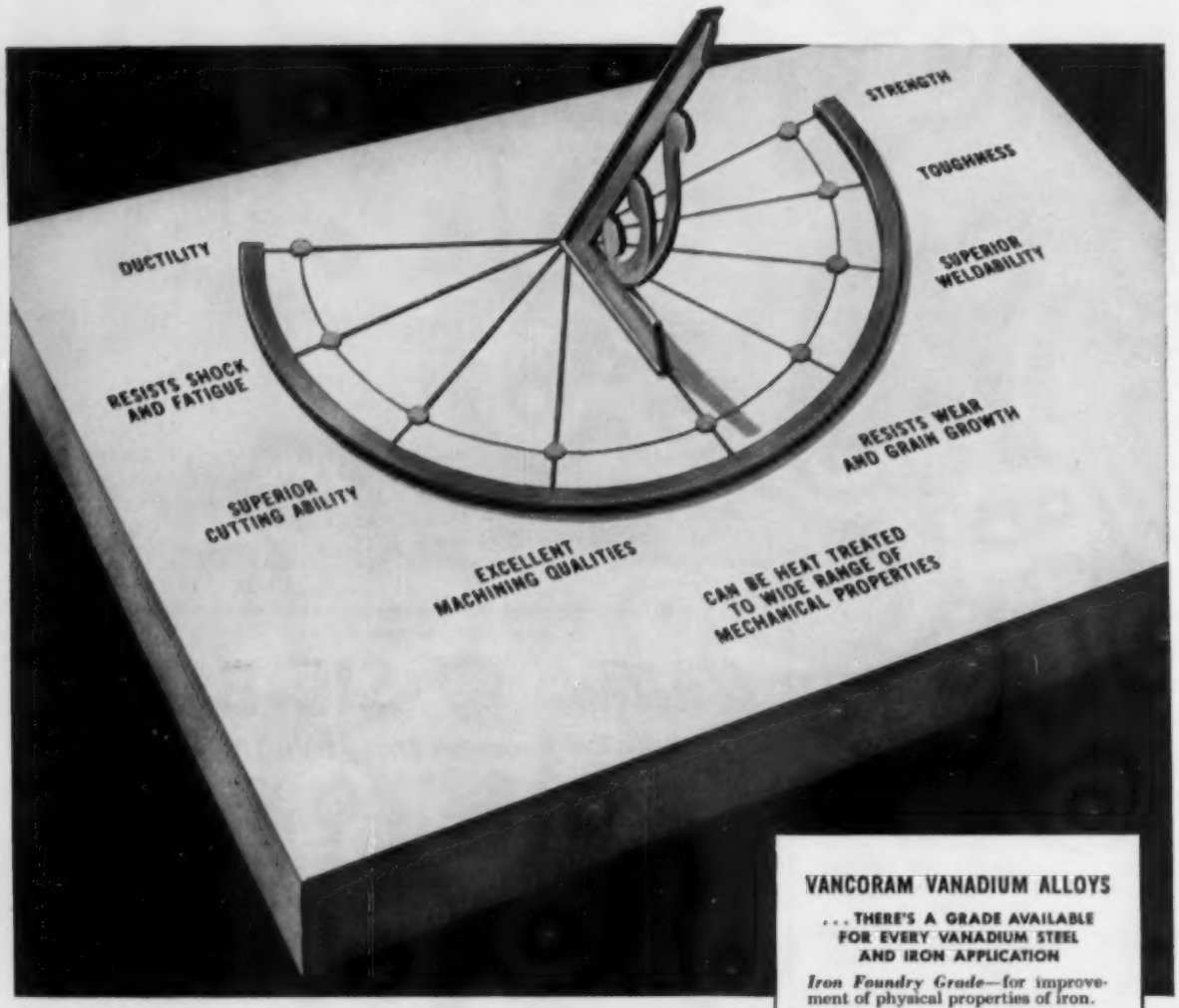
VERSATILE VANADIUM STEELS

for almost any property under the sun...



If you have a problem of meeting tough specifications, vanadium may help you do the job.

Either alone or in combination with other alloying elements, vanadium—in the form of Vancoram ferrovanadium—is one of the most versatile and dependable of alloying elements added to steel. It enhances the effect of other alloys and serves to improve the physical properties of the metal.

Just call our nearest sales office and we'll be happy to send a Technical Service representative to discuss your problem and offer recommendations.

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Iron Foundry Grade—for improvement of physical properties of iron.

Grade A (Open Hearth)—for low vanadium steels and vanadium cast irons.

Grade B (Crucible)—for tool steels and other high-vanadium steels requiring a limited silicon addition.

Grade C (Primos)—for making the highest vanadium and the lowest silicon addition to tool steels.

Vanadium Metal (90% grade)—for special iron-free (nonferrous) or low-iron alloys, or for low impurity ferrous alloys.

Vanadium Pentoxide, Tech.—a source of vanadium in basic electric-furnace steels. A base for numerous chemical compounds.

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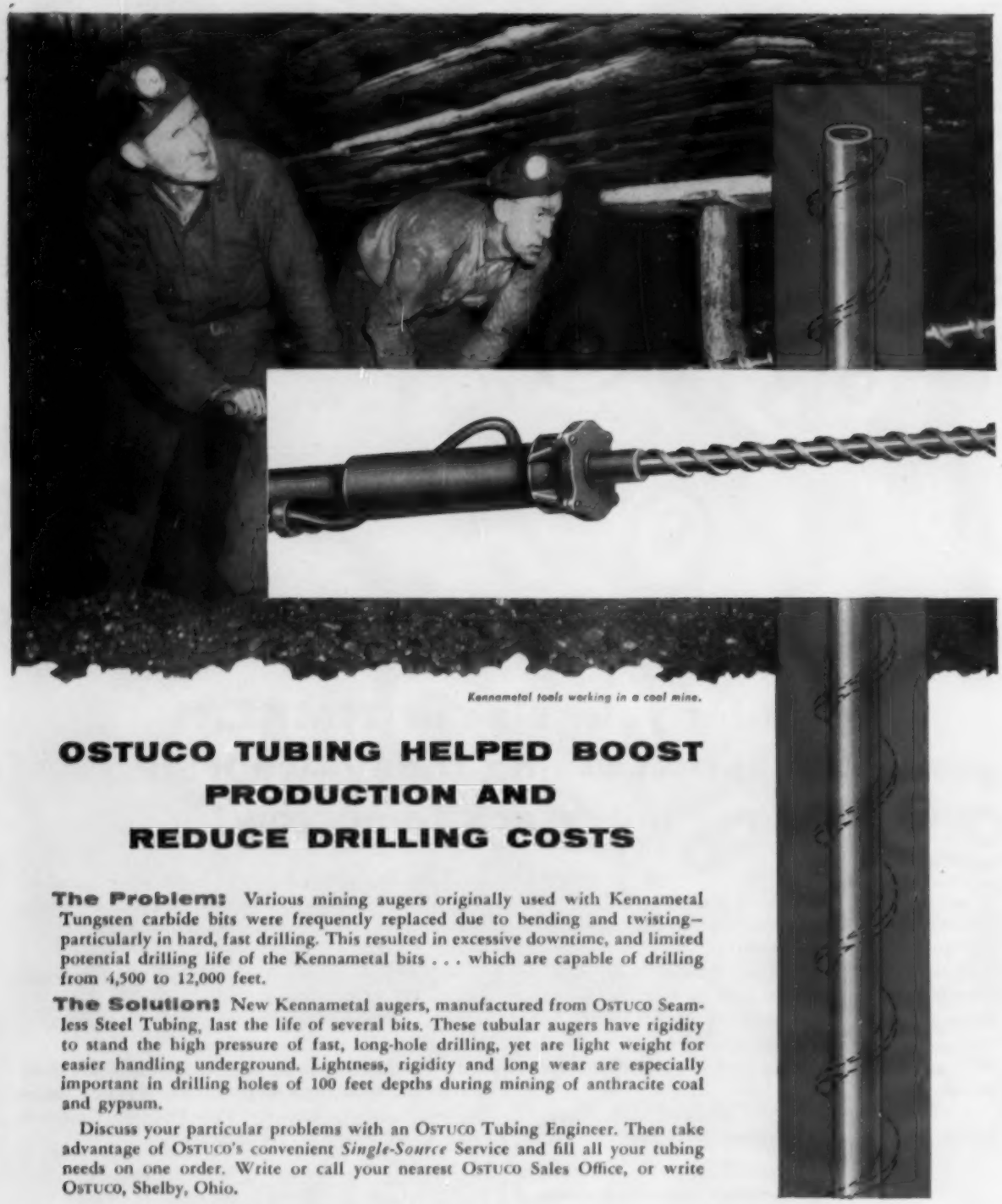
YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING



Kennametal tools working in a coal mine.

OSTUCO TUBING HELPED BOOST PRODUCTION AND REDUCE DRILLING COSTS

The Problem: Various mining augers originally used with Kennametal Tungsten carbide bits were frequently replaced due to bending and twisting—particularly in hard, fast drilling. This resulted in excessive downtime, and limited potential drilling life of the Kennametal bits . . . which are capable of drilling from 4,500 to 12,000 feet.

The Solution: New Kennametal augers, manufactured from OSTUCO Seamless Steel Tubing, last the life of several bits. These tubular augers have rigidity to stand the high pressure of fast, long-hole drilling, yet are light weight for easier handling underground. Lightness, rigidity and long wear are especially important in drilling holes of 100 feet depths during mining of anthracite coal and gypsum.

Discuss your particular problems with an OSTUCO Tubing Engineer. Then take advantage of OSTUCO's convenient *Single-Source* Service and fill all your tubing needs on one order. Write or call your nearest OSTUCO Sales Office, or write OSTUCO, Shelby, Ohio.

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What's New In Manufacturers' Literature . . .

311. Alloy Cast Iron
64-page bulletin A-71 on engineering properties and applications of Ni-Resist. Corrosion data compared with gray cast iron. *International Nickel Co.*

312. Alloy Steel
207-page book gives more than 50 complete case histories of alloy steel usage. *Climax Molybdenum.*

313. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

314. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

315. Alloy Steels
Comparable tables of SAE and AISI standard steels and tentative standard steels. *Babcock & Wilcox*

316. Allowable Stresses
Data Card 154 gives max. allowable stress values for 22 types of steel tubing. Formulas for calculation of max. working pressures. *Babcock & Wilcox*

317. Aluminum
4-page folder on standard and flattened expanded aluminum gives sizes, dimensions, weights for different mesh sizes. Applications. *Penn Metal Co.*

318. Aluminum
New 16-page brochure on aluminum mill products and how to use them. Wrought aluminum alloy selection guide. *Reynolds Metals Co.*

319. Aluminum Coating
Article on hot dip coating of ferrous metals with aluminum and aluminum alloys from "Tips and Trends." *Ajax Electric*

320. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

321. Aluminum Sheet
New wall chart gives weight and bend data on aluminum sheet in standard alloys. *Kaiser Aluminum & Chemical Sales*

322. Anodized Aluminum
Booklet on latest developments in coloring anodized aluminum. *Sandoz Chemical Works*

323. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

324. Atmospheres
New 12-page bulletin on use of protective atmospheres to prevent deterioration of metals during various heat treating processes. *General Electric*

325. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

326. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

327. Austempering
8-page booklet No. 500 on present status of austempering and martempering—development, S-curve theory, reasons for austempering and martempering. *Ajax Electric Co.*

328. Automatic Polishing
14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. *Murray-Way*

329. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chem.*

330. Bearings
4-page bulletin on plastic bearing materials. *Dixon Corp.*

331. Beryllium Copper
16-page booklet on applications and properties of beryllium copper. *Beryllium*

332. Beryllium Copper
Bulletin 1 on available alloys, conditions, tempers and tables of sizes and properties. *Penn Precision Products*

333. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal", describes 22 uses and gives engineering data. *W. M. Chace*

334. Blast Cleaning
8-page bulletin 1403 on liquid blast cleaning equipment. Drawings of cabinets. *Pangborn Corp.*

335. Brass Tubing
Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

336. Brazing
Bulletin 5889 on furnace and induction brazing installations and methods. *General Electric*

337. Brazing Alloys
Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

338. Brazing Stainless Steel
Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel", describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

339. Bronze
12-page bulletin on properties and uses of continuous cast bronze rod and tube. *American Smelting & Refining*

340. Carbon Control
New 12-page catalog TD4-620(2) on Microcarb atmosphere control for control of carbon potential in Homocarb furnaces. *Leeds & Northrup*

341. Carbon Steel Castings
Data folders on four types of carbon steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

342. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

343. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

344. Carburizing
Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs. time curves. Per cent carbon and nitrogen penetration curves. *American Cyanamid*

310. Fabricating Stainless
This Fabricator's Handbook considers the forming, machining, cutting, joining, heat treating, pickling and finishing of stainless steels. Brief descriptions, illustrations and tabular

data furnish the needed information. A side tabbed index makes it readily available. The last 64 pages of this 162-page book are given over entirely to reference data. In addition to the usual composition and property tables are extensive tables on corrosion resistance in various mediums and standard tolerances and weights for stainless sheet, strip, plates, circles, bars and tubing. *Crucible Steel Co. of America*

345. Carbon Steel Tubing
6-page booklet on hydraulic quality carbon steel tubing. Flow rate chart. *Superior Tube*

346. Castings
Bulletin on Ellis casting process, a new method for casting electronic components. *Howard Foundry*

347. Centrifugal Castings
Booklet on spun centrifugal castings of bronze for liners, rings, rolls, sleeves, bushings. *American Non-Gran Bronze*

348. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

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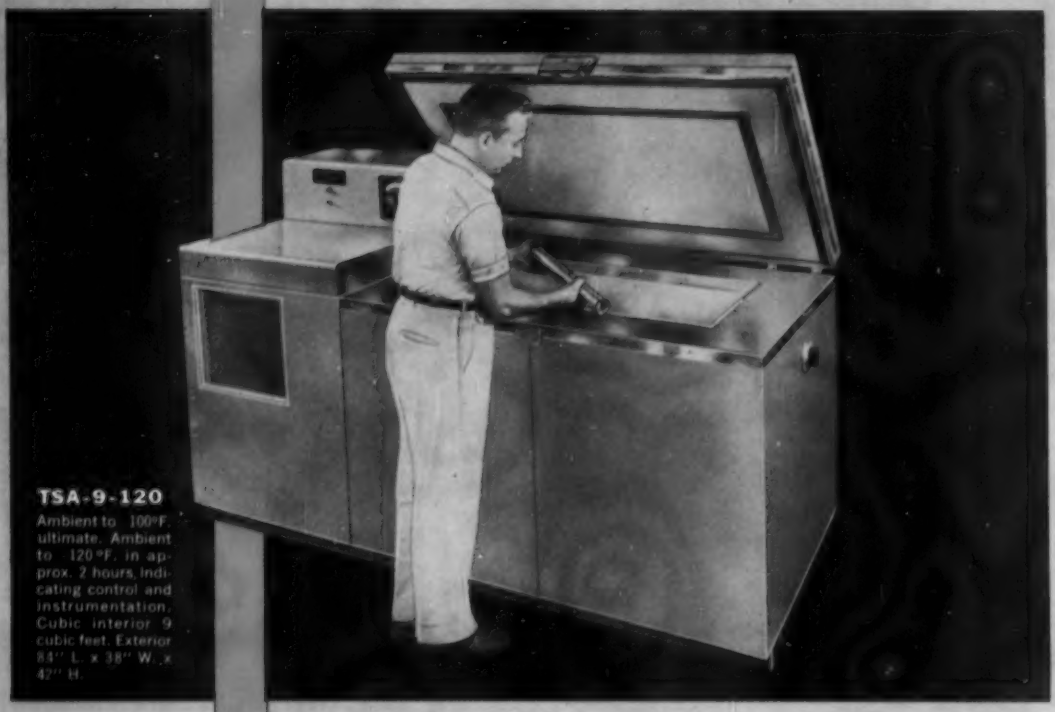

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Chilled metals do not oxidize or require additional finishing, and there is much less possibility of distortion of parts which have sections of various sizes.

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Engineers and Manufacturers of Refrigeration and Environmental Equipment

349. Cleaners
Folder on immersion, electrolytic, spray cleaners, phosphate coaters, strippers, drawing compounds, additive agents. *Northwest Chemical*

350. Cleaners
Bulletins on di-phase cleaners, specifications, equipment, advantages. *Solventol*

351. Cleaning
New 40-page catalog on detergents, wetting agents, brighteners and other chemicals. *Antara Chemicals*

352. Cleaning
Data sheets on acid activators to promote removal of scale and oxides from steel and iron. *Swift Ind. Chem.*

353. Coatings
Data sheet on industrial Protectox, tarnish-resistant coating for silver, silver alloys, copper, brass and gold. *Technic*

354. Cold Treatment
Bulletin on sub-Artic industrial cabinets for metal treating and research and production testing. *Tenney Eng'g.*

355. Controlled Atmospheres
Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

356. Controllers
46-page Bulletin 1120 on pneumatic control and transmission systems. Pneumatic controllers and how they work. *Minneapolis-Honeywell*

357. Controllers
12-page catalog of automatic controls for heat, speed, radiation, voltage, current, pH. *Assembly Products*

358. Copper Alloys
40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour Mfg.*

359. Corrosion of Copper
28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

360. Corrosion Prevention
8-page booklet on impressed current anodes for cathodic protection. *Duriron*

361. Corrosion Resistant Alloy
20-page booklet on nickel, chromium, molybdenum, iron alloy gives chemical composition, corrosion data, properties and welding characteristics. *Haynes Stellite*

362. Corrosion Resistant Tube
New bulletin TD117 on nickel-molybdenum and nickel-molybdenum-chromium stainless tubing and pipe. *Alloy Tube Div., Carpenter Steel Co.*

363. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

364. Cutting Oil
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

365. Cutting Tools
36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

366. Degreaser
40-page book on properties and use of trichlorethylene. Methods of handling and safety measures. *Niagara Alkali*

367. Degreasers
Folders on vapor and solvent degreasers describe equipment and advantages. *Ramco Equipment Corp.*

368. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

369. Descaling
Bulletin on new machines for descaling steel sheets, plates and coils after hot rolling or heat treating. *Pangborn Corp.*

370. Dew-Point Recorder
Bulletin 407 and Data Sheet AED 340-7 on dew-point systems for recording or controlling. *Foxboro*

371. Die Castings
Booklet on small zinc die castings. Types that can be made. Properties of zinc die casting alloys. *Gries Reproducer*

372. Die Castings
New booklet contains standard specifications, tolerance tables and physical properties of die casting alloys. *Parker White Metal Co.*

373. Dryers
Bulletin D-101 on dryers for air or gases gives descriptions and dew point and selection charts. *C. M. Kemp Mfg. Co.*

374. Electric Furnaces
8-page booklet on belt conveyer electric furnaces for bright hardening. *Westinghouse Electric Corp.*

375. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

376. Electric Furnaces
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

377. Electric Furnaces
New 12-page bulletin GEA 6236 on transformers for electric arc furnaces. *General Electric*

378. Electrolytic Grinding
12-page booklet on process, finishes that can be obtained, advantages. *Anocut Engineering Co.*

379. Electroplating
Bulletin TC-43441 on electrotinning of copper wire. *Baker & Adamson Products*

380. Electropolisher
Bulletin on theory and practice of electrolytic polishing of metallurgical samples. Descripton of electropolisher. *Buehler*

381. Extrusion Presses
8-page bulletin on aluminum extrusion presses describes the process and presses at work. *Watson-Stillman*

382. Fans
20-page catalog on forward curve and backward blade ventilating fans. *General Blower Co.*

383. Fasteners
New 12-page brochures 8-350 and 8-353 on shear aircraft bolts and shear aircraft bolt stump. *Huck Mfg. Co.*

384. Ferro-Alloys and Metals
104-page booklet gives data on more than 250 different alloys and metals produced by the company. *Electro Metallurgical*

385. Finishing
Bulletin on aluminum oxide barrel finishing compound for tumbling and precision finishing. *Simonds Abrasive Co.*

386. Finishing
Catalog A-654 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

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★ Save power
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Acitrol, the new, more efficient pickling inhibitor, withstands high temperatures for long periods—saves acid, saves steel, produces a better pickled finish.

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In addition to a full line of alkaline and emulsion cleaners, Houghton offers the new Houghto-Clean Cold Cleaners for both production line power washers and still or dip tank cleaning. These new cleaners are efficient, safe and require no heat!

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Both iron and zinc phosphate coatings: Houghto-Clean 313A is a highly efficient cleaner that produces an iron phosphate coating on the metal . . . aids paint adhesion. Houghto-Phos is a zinc phosphate treatment for subsequent drawing or painting operations.

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Houghton, the pioneer in rust prevention, has a complete line of Rust-Veto rust preventives for short term or long term protection of metal surfaces against rust and corrosion.

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Ready to give you on-the-job service . . .

387. Finishing
52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

388. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

389. Forging
20-page bulletin 355 on steam drop hammers. Dimension, designs, construction. *Erie Foundry Co.*

390. Forgings
Folder on large forgings of carbon and alloy steel. *Struthers Wells Corp., Titusville Forge Div.*

391. Forming Dies
Folder on styles of forming dies for stainless heads—in wide range of sizes and gages. *Carlson*

392. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

393. Furnaces
High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

394. Furnaces
Folder describes complete setup for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

395. Furnaces
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

396. Furnaces
16-page Bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineers*

397. Furnaces
Bulletin 451 and 341 on pit-type convection furnaces and multi-range convection furnaces. *Hevi Duty*

398. Furnaces
Folder on recuperative atmosphere furnaces for operation to 2500° F. *Lithium*

399. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

400. Furnaces
Data on luminous wall forging furnaces. *A. F. Holden*

401. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

402. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

403. Gamma Radiography
8-page catalog on gamma-ray radiography with radioactive cobalt 60 and iridium 192. *Mitchell Radiation Products*

404. Gas Pilots
Bulletin 151-155 on specifications and instructions for manually or electrically ignited pilots. *North American Mfg.*

405. Gold Plating
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

406. Graphite
20-page brochure on significance of graphite as electrodes, anodes, molds and specialties in electrometallurgy and electrochemistry. *Great Lakes Carbon*

407. Graphite Molds
Data on two types of molds for casting magnesium, steel, copper, brass and other metals. *National Carbon*

408. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

409. Grinding Wheels
28-page condensed catalog on grinding wheel selection. Specifications for many common applications. *Norton*

410. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

411. Hardness Tester
New bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. *Gries Industries, Inc.*

412. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

413. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

414. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

415. Hardness Testers
Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. *Wilson Mechanical Instrument*

416. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

417. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

418. Heat Treating Belts
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

419. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

420. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

421. Heat Treating Fixtures
24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

422. Heat Treating Pots
Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

423. High Alloy Castings
New 16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

424. High-Strength Bronze
12-page booklet on telnic bronze with high strength, high hardness, good machinability, age hardenability, corrosion resistance. *Chase Brass*

425. High-Strength Steel
28-page booklet on properties, uses, applications of high-tensile low-alloy steel. *Jones & Laughlin*

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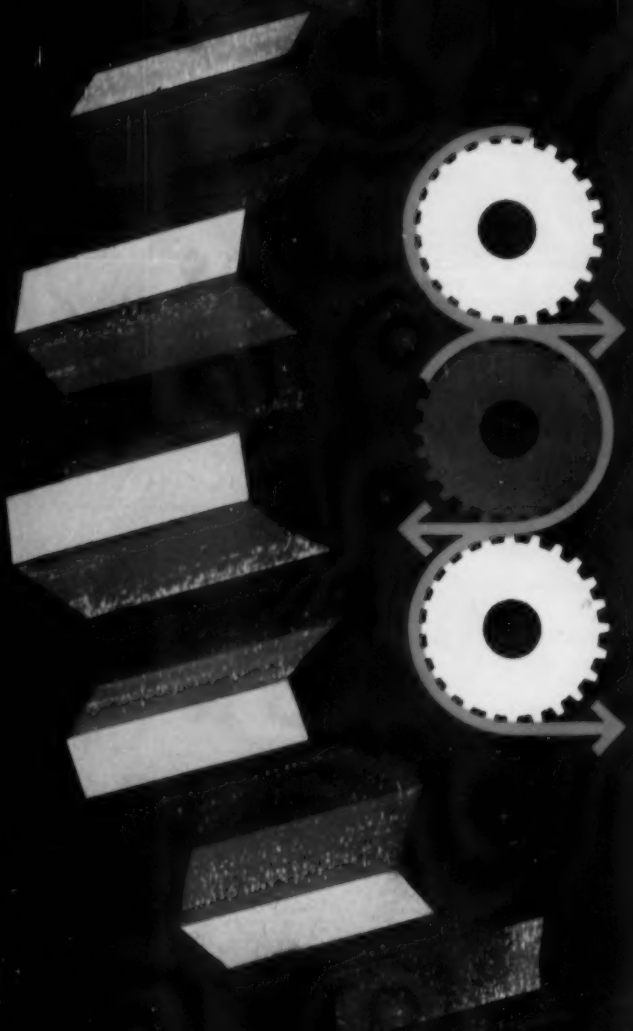

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Si 0.20/0.35	Cr 0.80/1.10	Mo 0.15/0.25	

4100 steels are your best bet

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MSS 13

426. High-Temperature Belts
New bulletin on belts of high-temperature alloy for heat treat furnaces. *Electro-Alloys Div.*

427. High-Temperature Steels
87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

428. Identifying Stainless
Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

429. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

430. Induction Heating
Folder 15C8053A gives advantages of induction heating and specifications and dimensions of induction heater. *Allis-Chalmers*

431. Induction Heating
Bulletin 1440 on system for safety control of induction heating through use of components built into every unit. *Lindberg Engineering*

432. Industrial Fans
Catalogs on various kinds of industrial fans — exhaust, multiblade, backward curve, for high temperatures. *Garden City Fan*

433. Industrial Heating
20-page handbook classifies industrial ovens and gives pointers on oven selection. *Michigan Oven Co.*

434. Insulation
40-page industrial products catalog on insulations, refractory products and others. *Johns-Manville*

435. Iron-Nickel Alloys
32-page bulletin on austenitic iron-nickel alloys having special thermal expansion or thermo-elastic characteristics. *International Nickel*

436. Joining Stainless
24-page booklet on various welding methods, soldering, brazing, flame cutting and arc cutting of stainless. *Crucible Steel*

437. Low-Alloy Steel
16-page bulletin A-61 gives corrosion resistance, forming and working qualities, design factors. *International Nickel Co.*

438. Low-Alloy Steel
60-page book on high-strength low-alloy steel, properties, fabrication and uses. *U. S. Steel*

439. Lubricant
4-page booklet lists 44 dispersions of graphite, molybdenum disulfide, mica, vermiculite, zinc oxide and acetylene black. *Acheson Colloids*

440. Lubricant
Literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

441. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

442. Machining Alloy Steels
24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

443. Malleable Iron
Reprint 51-B on metallurgy, treatment and heat treated properties of malleable iron. *Surface Combustion*

444. Melting Furnaces
28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

445. Melting Furnaces
8-page Bulletin 560 describes stationary and tilting types of two-chamber melting furnaces. Applications to all types of casting. *Lindberg Engineering*

446. Metallograph
20-page bulletin E-232 on Balphot metallograph with bright field, dark field, polarized light, phase contrast. *Bausch & Lomb*

447. Mold Heating
Discussion of heating molds for "Lost Wax" investment castings in Heat Treat Review, Vol. 5, No. 1. *Surface Combustion*

448. Molybdenum
24-page booklet gives physical and chemical properties data on molybdenum powders, wire, alloys. *Sylvania Electric*

449. Nickel Alloys
Wall chart gives engineering properties of nickel alloy wire, rod and strip. Includes Monel, Inconel, Incoloy and nickel-clad copper. *Alloy Metal Wire Co.*

450. Nickel-Plated Steel
Folder on method of electro-depositing thin nickel plate on sheet steel. Properties, applications. *Bart Mfg. Corp.*

451. Nitrogen Atmosphere
Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

452. Nodular Iron
8-page bulletin on nodular iron rolls and castings gives description and specifications for nodular iron, and how it is cast. *Aetna-Standard Engineering*

453. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

454. Nonferrous Casting
Folder on sand castings of bronze, aluminum and magnesium. *Springfield Bronze and Aluminum Co.*

455. Nonferrous Melting
Bulletin 26-A on high-frequency furnaces for melting copper, silver, gold, platinum, aluminum and magnesium. *Ajax Electrothermic*

456. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

457. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

458. Oil Quenching
Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

459. Phosphate Coatings
New 4-page pamphlet on line of phosphating coatings includes reference chart. *Turco Products*

460. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

461. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g.*

462. Piercing
Slide calculator for determining the required pressure (in tons) for piercing a given size hole in any thickness and type of metal. *Ward Machinery*

463. Plating Equipment
Bulletin on pencil for detecting "free" cyanide in plating solutions. *Pollack Products*

464. Plating Filters
7-page reprint on the use of filters in electroplating describes continuous, slurry tank, batch, sump and batch-sump filtration. *Alsop Engineering*

465. Plating Filters
Bulletin HH103 on filters for plating solution clarification and carbon treatment. *U. S. Hoffman*

466. Plating Racks
"Do-it-yourself" instructions for making plating racks. *Standard Rack*

467. Potentiometers
Article gives technical data on semi-precision potentiometers. *Rubicon*

468. Powder Metallurgy
12-page bulletin B-101 on furnaces for sintering powder metal products and reduction of metallic oxides. *Drever Co.*

469. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

470. Precision Castings
20-page book on alloys used, specification ranges, advantages and castings made by precision casting. *Haynes Stellite*

471. Precision Castings
16-page booklet includes composition and properties of carbon, low alloy, stainless, high temperature and tool steel precision castings. *Crucible Steel*

472. Proportioning Control
14-page booklet on new series of electric proportioning control. *Leeds & Northrup*

473. Pure Metals
Data sheets on vacuum melted cobalt, copper, iron and nickel. *Vacuum Metals*

474. Pyrometers
32-page thermocouple and accessory bulletin. *West Instrument*

475. Pyrometer Calibration
"Pyrometer Thermocouple Calibration Data" includes tables of data released by National Bureau of Standards. *Bristol Co.*

476. Pyrometer Supplies
New 16-page catalog or buyer's guide for thermocouples, protecting tubes, thermocouple wires, extension lead wires, insulators, accessories. *A. S. Richards*

477. Quench Agitation
32-page booklet on 1 to 500 hp. mixers, construction, operation, applications. *Mixing Equipment Co.*

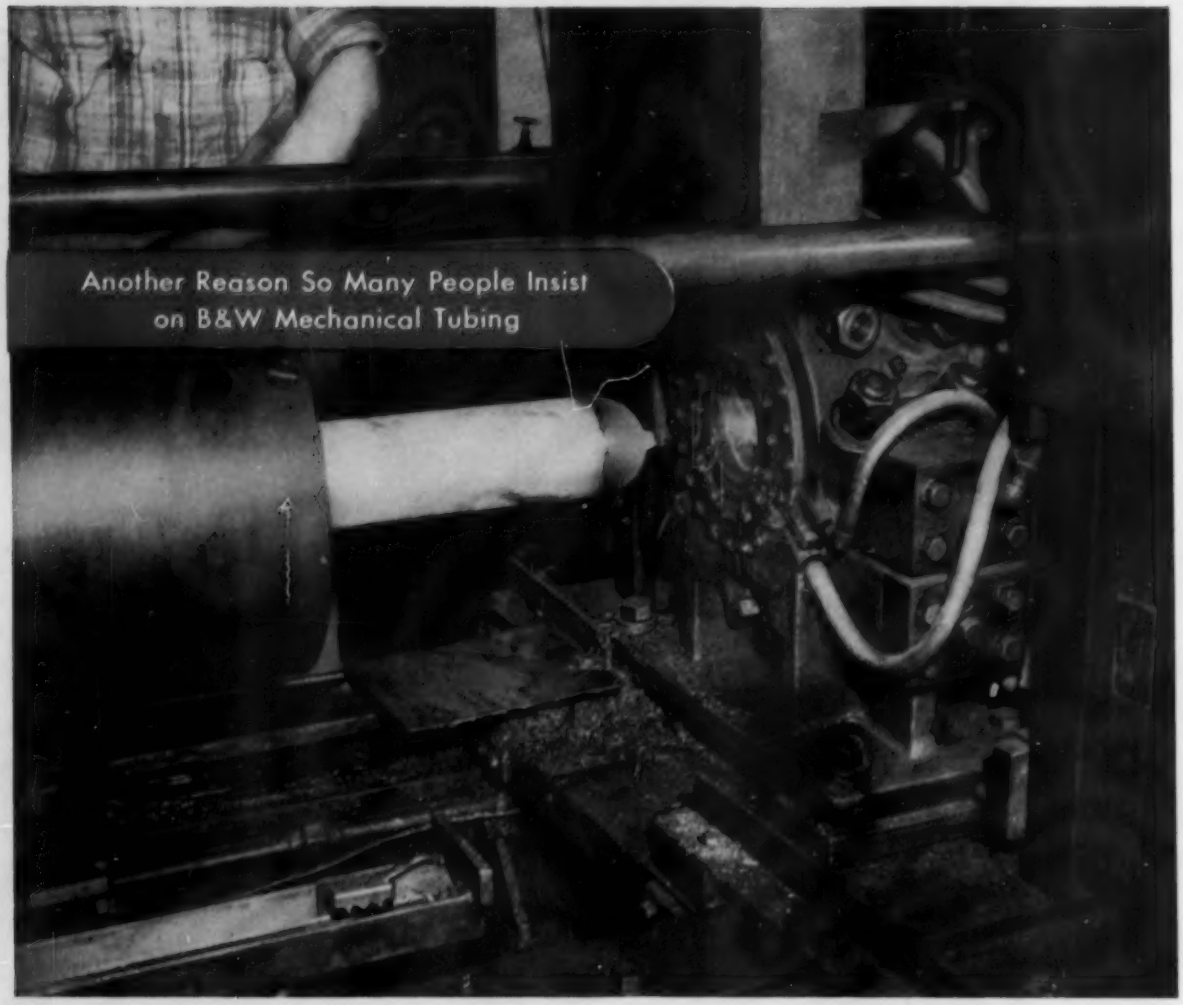
478. Quenching
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

479. Quenching Oil
New book on mechanism of quenching, properties of quenching mediums, cooling curves. *Gulf Oil*

480. Quenching Oil
8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

481. Quenching Oil
10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

(Continued on page 32-A)



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Alliance, Ohio: Welded Carbon Steel Tubing
Milwaukee, Wis.: Seamless Welding Fittings

TA-5006(M)

(Continued from p. 31)

482. Quenching Oils
8-page booklet on quenching c
cooling curves, hardnesses obtaine
Oil Co.

483. Radiamatic Pyrome
Catalog 9301 on four types of r
detectors for measuring temp
from 125 to 7000° F. *Minneapolis*
well

484. Radiation Protectio
12-page booklet on films for dete
amount of radiation. Used in
laboratories, nondestructive testi
oratories. *Du Pont*

485. Rare Earths
8-page Progress Report Number
Earths in Iron and Steel Melting."
denum Corp.

486. Refractories
24-page booklet on how refracto
is produced. Chemical and physic
acteristics, sizes available, appl
Norton

487. Refractories
New 24-page bulletin on physi
chemical properties of super refr
Applications. *Refractories Div., Ca*
dum

488. Refractory
12-page bulletin CR-11 on new c
refractory gives properties, s
processing methods, uses. *Rich*
Remmey Son Co.

489. Refractory Coating
Data on aluminum oxide and
carbide coating which may be
on. *Norton Co.*

490. Roll Forming
Bulletin 854 on roll forming
rolled shapes. *American Roller D*

491. Roll Formed Shape
24-page Bulletin 1053 on de
forming and producing shapes fr
rous and nonferrous metals. *Roll*
Products Co.

492. Rolling Mills
New 8-page bulletin on 2-hig
rolling mills. Design, construction
bury Farrel Foundry & Machine

493. Rust Preventives
12-page bulletin on water-solub
preventive. *Production Specialtie*

494. Rustproofing
19-page booklet on vapor phas
itor papers for corrosion-proof wr
Angier Corp.

BARBER COLMAN

New Wheelco Model 405 Capacitrol

Get the finest temperature control available for fuel-fired furnaces and ovens by specifying Wheelco's new Model 405 Capacitrol. For the ultra-sensitive control action of the "405" prevents wide temperature differentials, saves fuel, and prevents fast depreciation of heating equipment caused by stop-and-go, on-off control. "Heart" of the instrument is its ultra-sensitive, yet extremely stable Micropositioner — an exclusive Wheelco development, which positions the valve actuator directly from the controller's electronic circuit. For details, write for Bulletin F-6314-1.

New Wheelco Combustion Safeguard
Now . . . "safe-start" operation for oil- and gas-fired combustion equipment is yours with the new Wheelco combustion safeguards — manual or automatic Flame-otrols. Designed for easy servicing. See new features in Bulletin F-6570.

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METAL

(Continued from p. 31)

482. Quenching Oils
8-page booklet on quenching oil gives cooling curves, hardnesses obtained. *Shell Oil Co.*

483. Radiamatic Pyrometers
Catalog 9301 on four types of radiation detectors for measuring temperatures from 125 to 7000° F. *Minneapolis-Honeywell*

484. Radiation Protection
12-page booklet on films for determining amount of radiation. Used in research laboratories, nondestructive testing laboratories. *Du Pont*

485. Rare Earths
8-page Progress Report Number 1, "Rare Earths in Iron and Steel Melting." *Molybdenum Corp.*

486. Refractories
24-page booklet on how refractory grain is produced. Chemical and physical characteristics, sizes available, applications. *Norton*

487. Refractories
New 24-page bulletin on physical and chemical properties of super refractories. Applications. *Refractories Div., Carborundum*

488. Refractory
12-page bulletin CR-11 on new crystalite refractory gives properties, analyses, processing methods, uses. *Richard C. Remmey Son Co.*

489. Refractory Coating
Data on aluminum oxide and silicon carbide coating which may be sprayed on. *Norton Co.*

490. Roll Forming
Bulletin 854 on roll forming of cold rolled shapes. *American Roller Die Corp.*

491. Roll Formed Shapes
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

492. Rolling Mills
New 8-page bulletin on 2-high strip rolling mills. Design, construction. *Waterbury Farrel Foundry & Machine Co.*

493. Rust Preventives
12-page bulletin on water-soluble rust-preventive. *Production Specialties*

494. Rustproofing
19-page booklet on vapor phase inhibitor papers for corrosion-proof wrappings. *Angier Corp.*

495. Salt Baths
32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

496. Salt Baths
28-page book deals with heat treatment, carburizing, bath maintenance, safety precautions. *American Cyanamid*

497. Salt Bath Furnaces
Data on electric, gas salt bath furnaces. *Bellis*

498. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

499. Saws
Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

500. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

501. Silver Brazing
Series of eight technical bulletins on silver brazing. Joint strength, design, stress analysis, heat treatment, fluxes. *Handy & Harman*

502. Silver Brazing
48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

503. Silver Plating
4-page booklet on high speed silver plating process gives data on bath preparation, procedures, thickness requirements. *Sel-Rex*

504. Sintered Carbides
New 24-page booklet on the characteristics of the various grades, for research and design engineers. *Kennametal*

505. Slitters
New 24-page booklet on gang slitters and accessory equipment. Standard and custom engineered slitters. *Waterbury Foundry & Machine Co.*

506. Sodium
New 28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. *Ethyl Corp.*

507. Sodium Metal
24-page book on sodium in colloidal form, spread over inert solids of high surface area. Applications. *U. S. Industrial Chem.*

508. Spark Testing
20-page spark test guide features spark diagrams of 13 standard tool and die steels. *Carpenter Steel*

509. Specifications Index
28-page cross index lists copper alloy specifications of nine different Government agencies. *American Brass*

510. Spinning
New booklet on hydrospinning techniques and machines. *Cincinnati Milling Machine Co.*

511. Spot Welding
12-page reprint on spot welding from one side with a portable gun. *Air Reduction Sales*

512. Stainless Fasteners
8-page brochure on styles and sizes of screws, nuts, washers, rivets, nails, pins. *Allmetal Screw Products*

513. Stainless Steel
Booklet on 430 stainless. Properties, fabrication. *Sharon Steel*

514. Stainless Steel
Selector gives machinability, physical and mechanical properties, corrosion resistance of various grades of stainless steel. *Crucible Steel*

515. Stainless Steel
Wall chart gives engineering properties of 20 different stainless steel alloys available in wire, rod and strip. *Alloy Metal Wire*

516. Stainless Tubing
Folder TB-355 on seamless stainless tubing and pipe. Specifications, sizes, fabrications possible. *Babcock & Wilcox*

517. Stainless Tubing
40-page catalog, section 20, on alloys used, fabrication and working, pickling process. Sections on welding, soldering, brazing, machinability of heat resisting steels. *Superior Tube Co.*

518. Stamping
New 12-page catalog on stamping, drawing, forming and heading. *Plume & Atwood Mfg.*

519. Stampings
Bulletin on making from 100 to 40,000 stampings per hour. *Laminated Shim Co., Stampings Div.*

520. Steel
256-page handbook lists sizes, weights, lengths, steels available, shapes. Data on mechanical properties, standard steel

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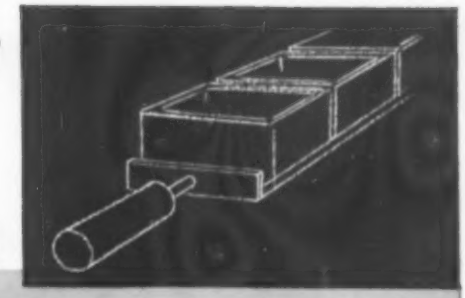

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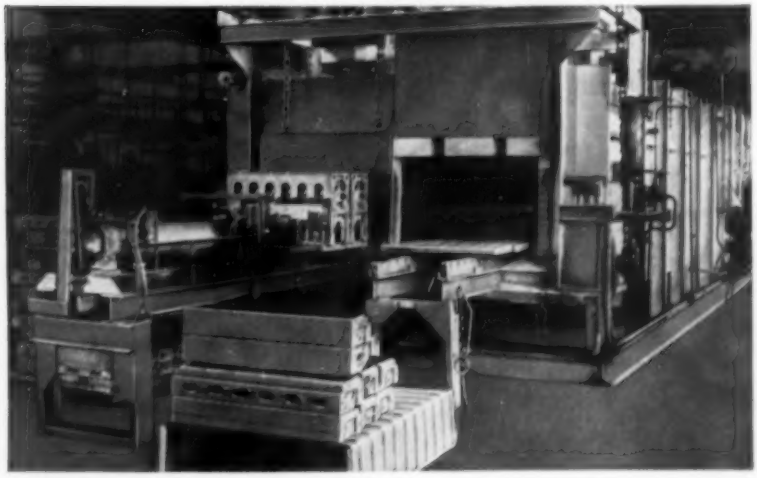

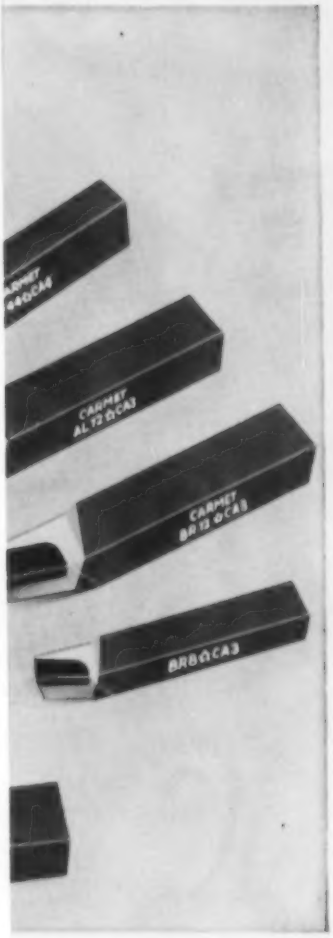

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compositions, hardness numbers conversions. *Ryerson*

521. Stress-Strain Recorders

New 28-page bulletin No. 4215 on 16 standard recorders and 50 models of strain followers, for use on standard testing machines. *Baldwin-Lima-Hamilton*

522. Sub-Zero Treatment

New 12-page booklet on industrial chilling equipment for shrinking, testing and treating of metals. *Cincinnati Sub-Zero Products*

523. Tempilstiks

"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. *Claud S. Gordon*

524. Tester

Bulletin 164 on Dyhedron, dynamic diamond tester for hardness and lubricity of materials. *Taber Instrument.*

525. Testing Machines

28-page catalog on screw power universal testing machines and accessories. Construction, specifications. *Riehle*

526. Textured Stainless

Folder on stainless to conserve alloys and reduce weight. *Rigidized Metals*

527. Thermocouple Data

42-page Bulletin TC-9 on thermocouples, radiation detectors, resistance bulbs, accessories. *Wheelco*

528. Thermocouple Elements

New bulletin on general application data for various types of elements and different metals. *Claud S. Gordon Co.*

529. Thermocouple Wires

4-page bulletin on ceramic insulated thermocouple wires and thermocouple extension wires. *Thermo Electric*

530. Thermocouples

20-page Bulletin 714 on thermocouples, protecting tubes and wells, insulators, leads, connectors, heads. *Gen. Electric*

531. Thermocouples

36-page Bulletin 235-4 describes various types of thermocouples, extension wire and other accessories. *Foxboro*

532. Thickness Testers

6-page catalog on Audigage thickness testers. Characteristics and applications of five models. *Branson Instruments*

533. Tool & Die Steels

28-page guide to qualities and sizes available. *Uddeholm*

534. Tool Steel Failures

124-page book, "Tool Steel Trouble Shooter", analyzes 107 tool failures and assigns causes as among tool design faults, tool steel faults, improper heat treatment, mechanical and operational factors. *Bethlehem Steel*

535. Tool Steel Guide

New 70-page brochure includes information on 50 types of tool steels and cold finishing products. *Vanadium-Alloys Steel*

536. Tool Steels

Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand casting, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

537. Tubing Handbook

Handbook E-4 on resistance welded steel tubing. *Ohio Seamless Tube*

538. Tumbling Abrasive

Bulletin on tumbling abrasive for deburring or precision finishing. *Simonds Abrasive*

539. Tumbling Barrel

New bulletin on tumbling barrels includes data on selection of abrasive compounds. *Tumb-L-Matic*

540. Tungsten Carbide

72-page catalog on tungsten carbide products, including tools, dies, gages, rolls. *Metal Carbides Corp.*

541. Ultrasonic Cleaning

Bulletin DR-400 on ultrasonic equipment for production cleaning and degreasing. *Acoustica Associates*

542. Vacuum Coating

Bulletin on principles, production steps, applications, equipment. *National Research*

543. Vacuum Metallurgy

Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. *National Research*

544. Vacuum Pumps

Bulletin 400 on mechanical booster high vacuum pumps. *Kinney Mfg. Div.*

545. Vanadium Products

12-page brochure on 25 steel, iron, aluminum and chemical products. Composition and applications. *Vanadium Corp.*

546. Voltmeters

Bulletin E1111 on series 500 recording voltmeters and ammeters. *Bristol Co.*

547. Welding

Three bulletins on recently developed Fillerarc consumable-electrode gas-shielded welding process. *General Electric*

548. Welding Alloy Steel

44-page Data Book 4D covers all types of welding of nickel alloy steels. *International Nickel*

549. Welding Copper

24-page booklet on oxyacetylene, carbon-arc and metal-arc welding techniques for copper and copper alloys. *Revere*

550. Welding Electrodes

50-page book on electrodes of stainless, mild and high-tensile steels, cast iron, nonferrous alloys, low-hydrogen and hardfacing compositions. *Air Reduction*

551. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

552. Welding Magnesium

Various welding processes for magnesium, stress relief and recommended procedures. *Brooks & Perkins*

553. Welding Positioners

New bulletin gives suggestions to aid in choice of right welding positioner. *Worthington Corp.*

554. Welding Rods

6-page bulletin on bronze welding rods. Table gives ASTM, AWS and Government specifications. *Titan Metal*

555. Welding Stainless

8-page Bulletin GET-1955 gives arc-welding practices for stainless steels. *General Electric*

556. Wire Cloth

84-page booklet on applications, meshes, baskets, filters. *Cambridge Wire Cloth*

557. X-Ray Equipment

Bulletins on No. 2 SPG X-ray detector describe specifications and advantages. *X-ray Dept., General Electric*

558. X-Ray Supplies

50-page catalog of industrial X-ray supplies and accessories. *Westinghouse*

559. X-Ray Unit

New 4-page bulletin gives design details and application data for portable X-ray unit. *North American Philips Co.*

560. Zinc

New 32-page booklet on how zinc controls corrosion, gives data on zinc coatings, pigments, anodes. *American Zinc Institute*

AUGUST, 1955

271	296	321	346	371	396	421	446	471	496	521	546
272	297	322	347	372	397	422	447	472	497	522	547
273	298	323	348	373	398	423	448	473	498	523	548
274	299	324	349	374	399	424	449	474	499	524	549
275	300	325	350	375	400	425	450	475	500	525	550
276	301	326	351	376	401	426	451	476	501	526	551
277	302	327	352	377	402	427	452	477	502	527	552
278	303	328	353	378	403	428	453	478	503	528	553
279	304	329	354	379	404	429	454	479	504	529	554
280	305	330	355	380	405	430	455	480	505	530	555
281	306	331	356	381	406	431	456	481	506	531	556
282	307	332	357	382	407	432	457	482	507	532	557
283	308	333	358	383	408	433	458	483	508	533	558
284	309	334	359	384	409	434	459	484	509	534	559
285	310	335	360	385	410	435	460	485	510	535	560
286	311	336	361	386	411	436	461	486	511	536	
287	312	337	362	387	412	437	462	487	512	537	
288	313	338	363	388	413	438	463	488	513	538	
289	314	339	364	389	414	439	464	489	514	539	
290	315	340	365	390	415	440	465	490	515	540	
291	316	341	366	391	416	441	466	491	516	541	
292	317	342	367	392	417	442	467	492	517	542	
293	318	343	368	393	418	443	468	493	518	543	
294	319	344	369	394	419	444	469	494	519	544	
295	320	345	370	395	420	445	470	495	520	545	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

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Name _____

Title _____

Company _____

Address _____

City and State _____

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36 pages; grades, tool styles, sizes, etc.

METHODS MANUAL
20 pages on speeds, feeds, cuts, etc.

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The Allegheny Ludlum line of Carmet Carbide Tools is *complete*—every style, size and grade you may need for any cutting job in the shop. If you make your own tools, a full line of blanks is available, too—as well as all necessary sizes of A-L Shank Steel. Extensive stocks of Carmet standard tools and blanks are carried in Distributors' warehouses coast to coast, and special tools are available to order. • Just remember, for best performance on any application, *use Carmet! Allegheny Ludlum Steel Corporation, Carmet Division, Wanda and Jarvis Avenues, Detroit 20, Michigan.*

WAD 5570

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AL® FINE TOOL STEELS SINCE 1854

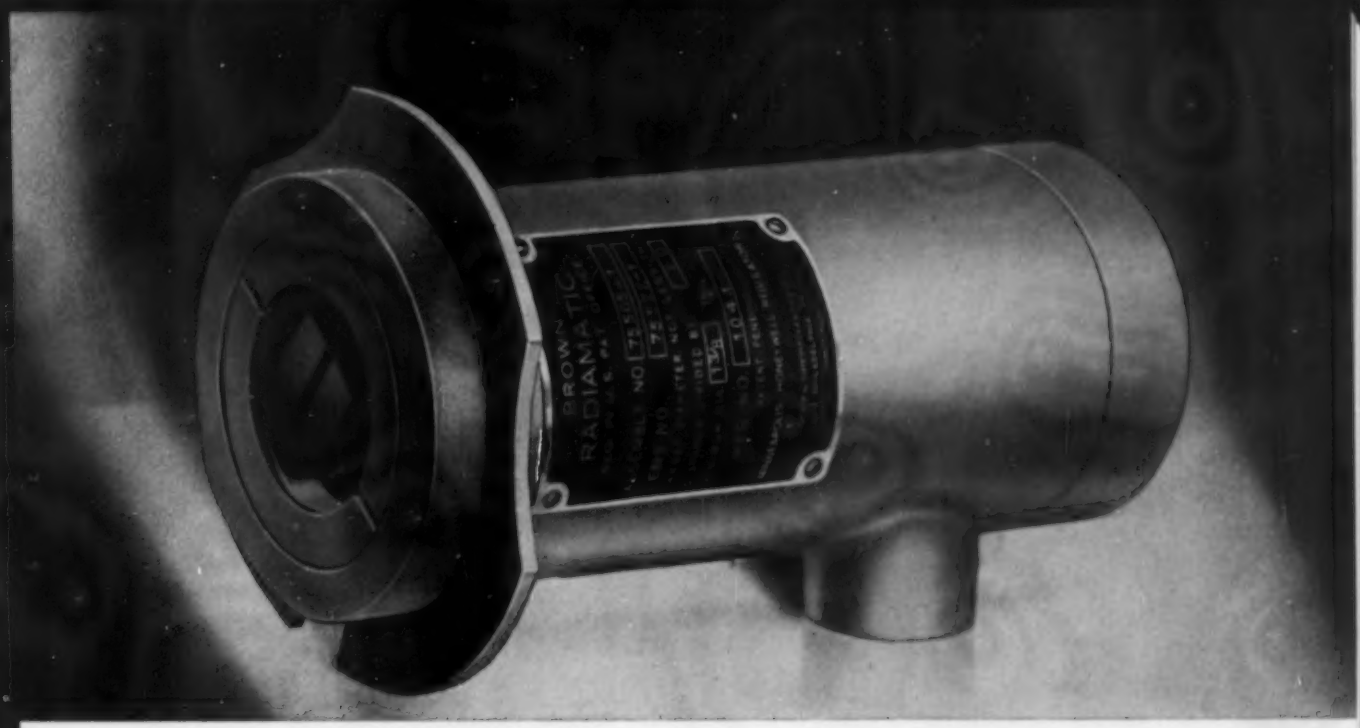
New Radiamatic

PYROMETER

catches any temperature

Compare these performance features—

Fast response speed	0.4 seconds for 98% change in temperature.
Ambient temperature compensation	automatic for temperatures up to 250F.
Distance factor	both narrow angle and wide angle types available for various target sizes.
Choice of ranges	800 to 1900F. or 1000 to 2600F.
Instrument	*ElectroniK* potentiometer with 1-second full scale response.
Simple mounting	compact unit is readily installed with standard hardware, same as general purpose *Radiamatic*. Rear sighting window is available to assist installation.



change in less than 1/2 second

. . . adds new areas of application to the realm of pyrometric measurement

GOT fast-changing temperatures to measure or control?

This latest model of the *Radiamatic* pyrometer is what you need. Its split-second response brings a new level of speed and accuracy to a whole host of vital temperature measurements.

- **In rolling operations,** it catches temperatures of fast-moving bars, billets and sheets . . . follows temperatures so faithfully that it can get you accurate distribution curves along the length of the piece being rolled.
- **In heating operations** the new *Radiamatic* element makes possible precise, automatic shut-off of fuel or power in high-speed heating . . . the instant that critical temperatures are reached.

The secret of this unusual performance is a new kind of design, that puts the principle of radiation pyrometry to work at higher speed than ever before. 98% of any temperature change is detected in less than one-half second!

In precision, too, the new design excells. Sudden changes in ambient temperature, due to drafts, opening of furnace doors and the like, won't introduce errors in measurement. The unit can be mounted in "hot spots," where ambient temperatures get as high as 250F., without affecting its calibration.

The instrument that works best with the *Radiamatic* element is a high speed *ElectroniK* recorder, which can be supplied with a wide variety of signalling and controlling functions. For a discussion of how you can utilize this new standard of measuring performance in your own production, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:** Write for Bulletin 9320, "New High Speed *Radiamatic* Detector."

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

WE WELCOME YOU

to a New Era of Electrode Performance

AN EXCLUSIVE STEP FORWARD ....

in the techniques of electrode manufacture now gives GLC graphite electrodes a coefficient of expansion lower than any other electrode on the market today.

The resultant rugged resistance of GLC graphite electrodes to thermal shock substantially reduces breakage and spalling, and affords worthwhile economies in electric steel production.

This achievement is a result of a high degree of integration between discoveries in our research laboratories, refinements in processing raw materials, and improved techniques in electrode manufacture.

Lower operating costs experienced by our customers are a reflection of our partnership in their progress, and point the way to a new era of electrode performance for the electric furnace steel industry as a whole.

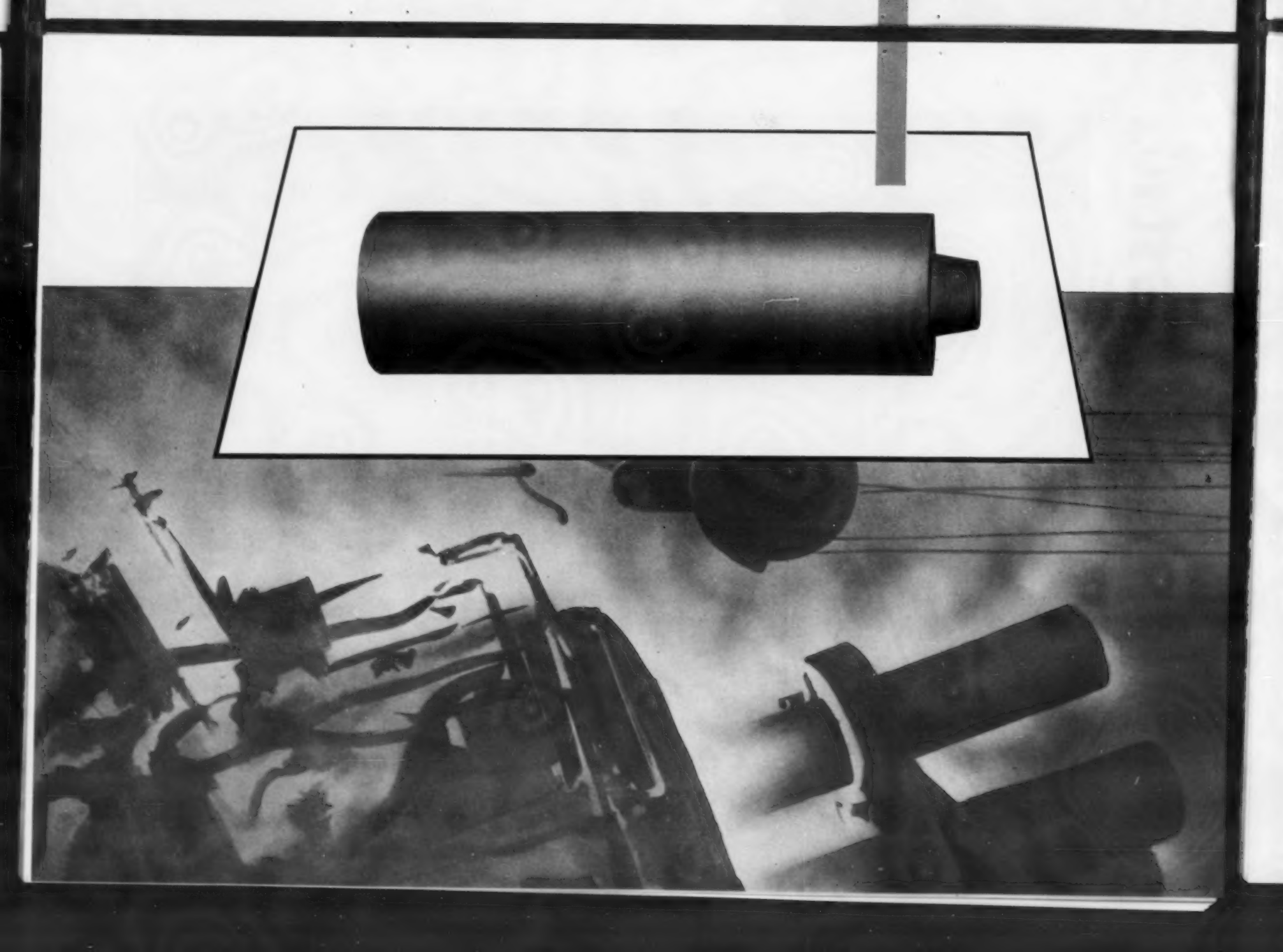
GLC ELECTRODE DIVISION

Great Lakes Carbon Corporation

GRAPHITE ELECTRODES, ANODES, MOLDS and SPECIALTIES

ADMINISTRATIVE OFFICE: 18 East 48th Street, New York 17, N. Y.
PLANTS: Niagara Falls, N. Y., Morganton, N. C.
OTHER OFFICES: Niagara Falls, N. Y., Oak Park, Ill., Pittsburgh, Pa.

Sales Agents in Other Countries: Great Northern Carbon & Chemical Co., Ltd., Montreal; Overseas Carbon & Coke Company, Inc., Geneva; Great Eastern Carbon & Chemical Co., Inc., Chiyoda-Ku, Tokyo.



To cut forging costs ...

WHENEVER a customer for aluminum forgings submits a design to Kaiser Aluminum's Erie Forging Plant, our engineers study it closely to see if we can lower costs, improve the design, or both.

And time after time, this second look results in big savings for customers on dies and pieces. Here are a few typical examples ...

If you are now buying aluminum forgings, let our engineers review your designs with a view to effecting savings like those illustrated here.

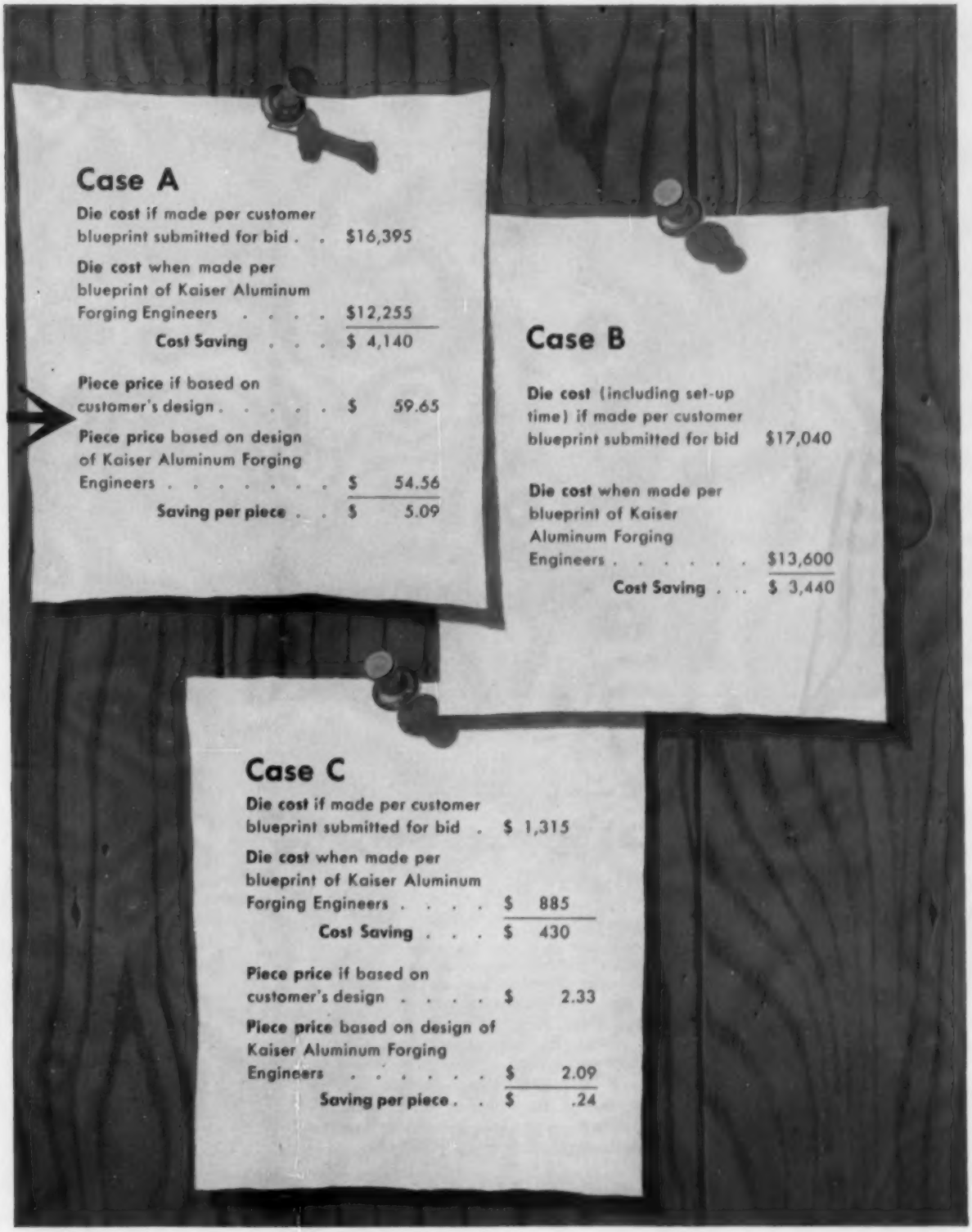
If you have not yet converted to aluminum forgings, why not investigate now? Our engineers will be glad to work with you to help you get a better product at lower cost.

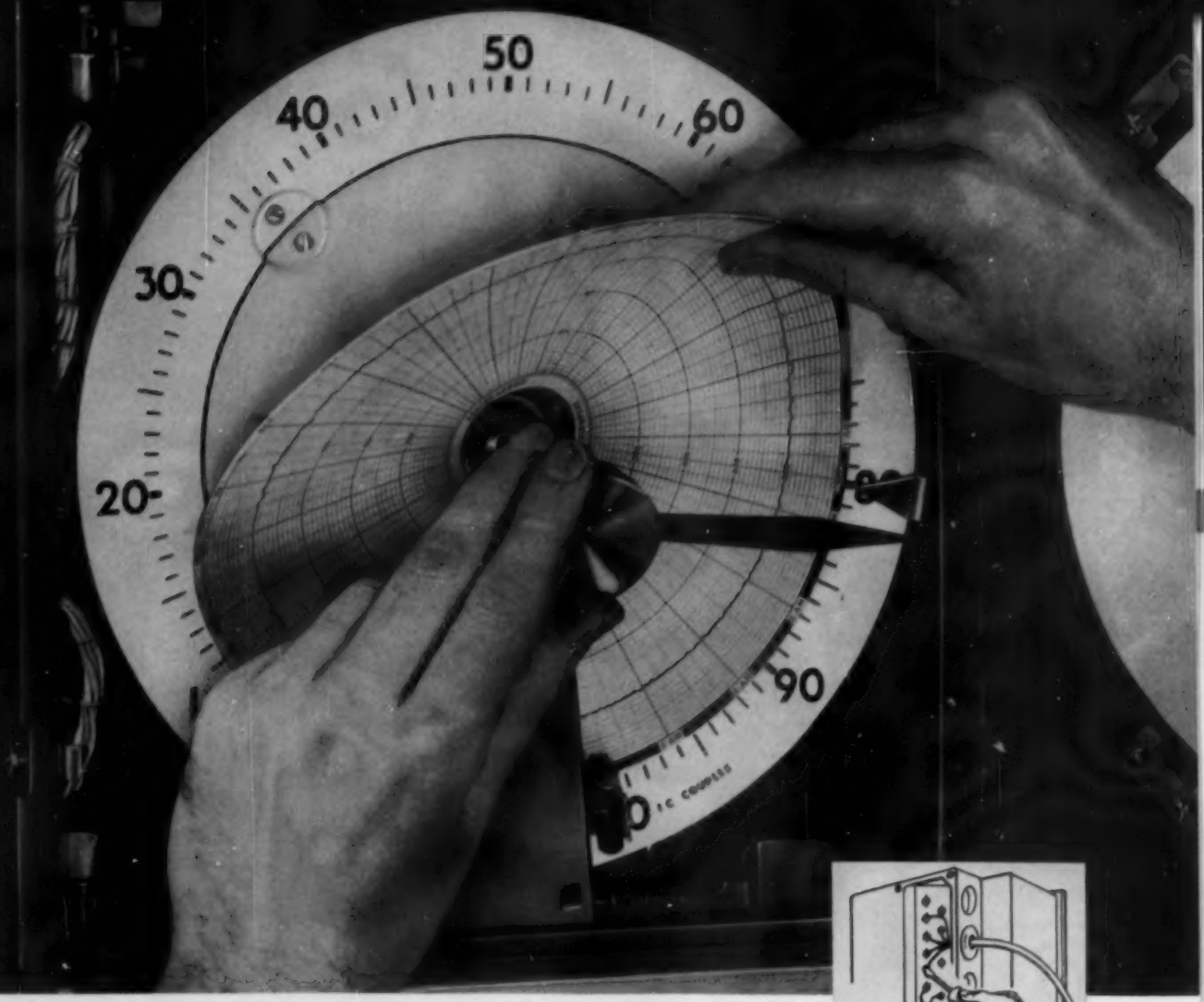
Take advantage of Kaiser Aluminum Forging Consultation Service without delay. Contact any Kaiser Aluminum Sales Office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum

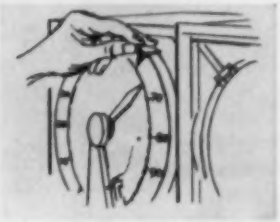
setting the pace—in growth, quality and service

think of Kaiser Aluminum


Case A
Die cost if made per customer blueprint submitted for bid . . $16,395
Die cost when made per blueprint of Kaiser Aluminum Forging Engineers $12,255
Cost Saving . . . $ 4,140
Piece price if based on customer's design . . . . . $ 59.65
Piece price based on design of Kaiser Aluminum Forging Engineers . . . . . $ 54.56
Saving per piece . . $ 5.09
Case B
Die cost (including set-up time) if made per customer blueprint submitted for bid $17,040
Die cost when made per blueprint of Kaiser Aluminum Forging Engineers $13,600
Cost Saving . . . $ 3,440
Case C
Die cost if made per customer blueprint submitted for bid . $ 1,315
Die cost when made per blueprint of Kaiser Aluminum Forging Engineers . . . . $ 885
Cost Saving . . . $ 430
Piece price if based on customer's design . . . . $ 2.33
Piece price based on design of Kaiser Aluminum Forging Engineers . . . . . $ 2.09
Saving per piece . . $ .24



To put in operation, simply connect leads to back of case . . .



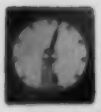
. . . set control point setter
. . . turn on power switch.

To see the features of this new line, get our pictorial fold-out. Phone your nearest L&N office or write us at 4927 Stenton Ave., Phila. 44, Pa. and ask for Die-Out ND46(1).

A new concept in . . .

operating ease

WITH SPEEDOMAX® H



Although this round chart Speedomax H is small in size, you can set the control point or read it from a distance almost as easily as "big" instruments. For the easy-to-see control and indicating pointers travel around a large 23-inch scale. Chart changes take less than a minute!

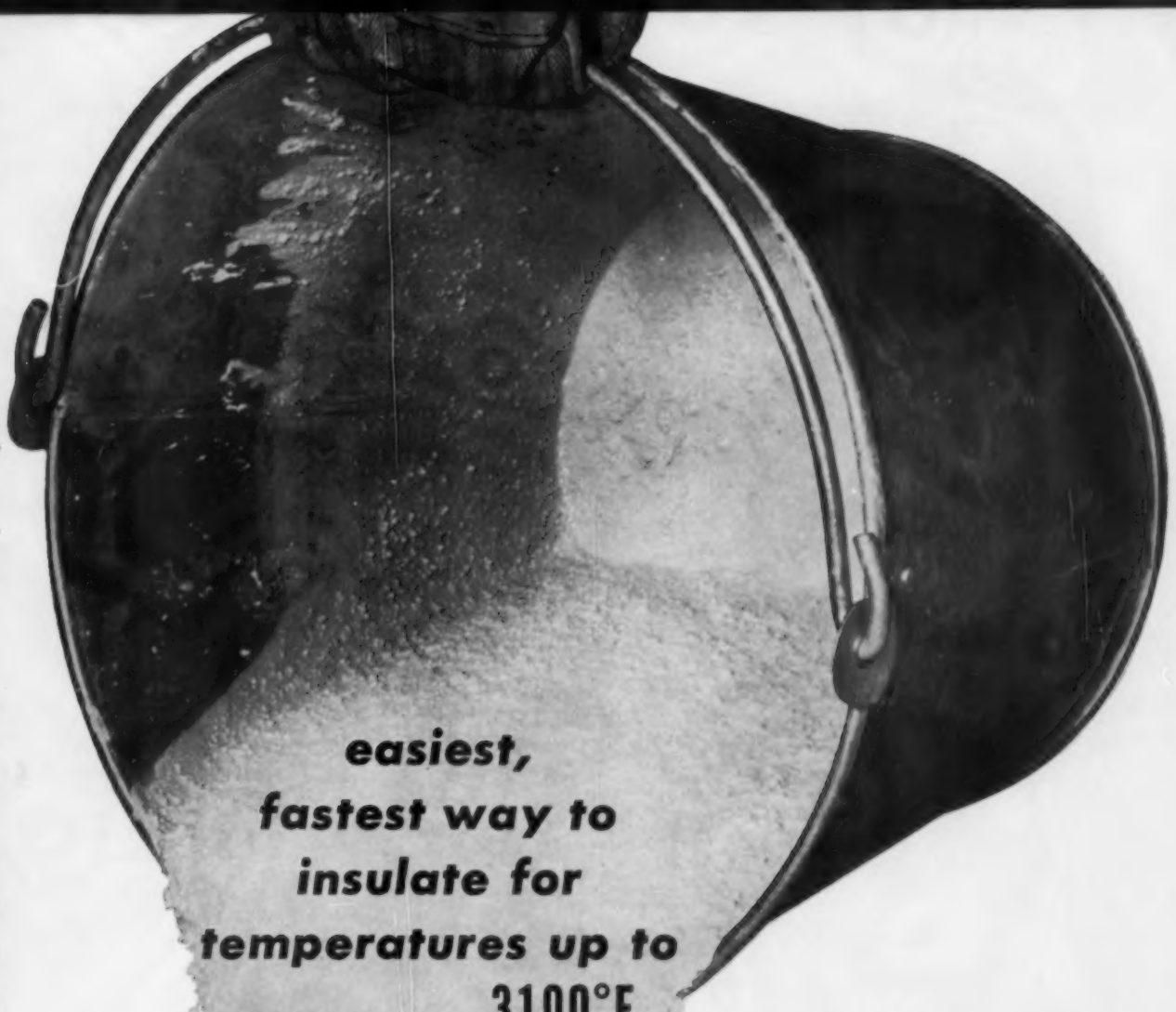
All wiring connections are made to an external terminal board, at rear of the case. If you move the instrument from job to job, range changes can be made on the spot. A screw driver is the only tool you need.

Whether you're using a simple indicator or a 3-action controller, all components are in one compact unit. Relays, amplifiers, etc., have plug-in connections.

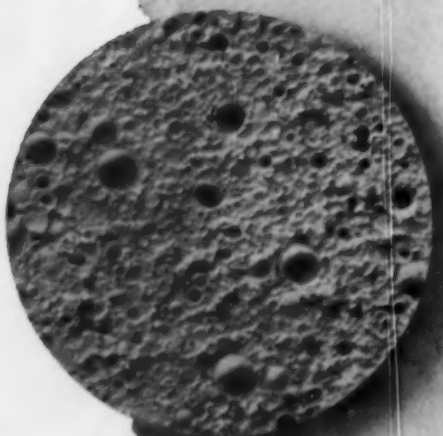
In short here's a complete line of null-balance potentiometers available for a broad-range of temperature measurements including many now being made with non-potentiometer instruments.

LEEDS LN NORTHRUP

instruments — automatic controls • furnaces



easiest, fastest way to insulate for temperatures up to 3100°F



Here's why ALFRAX cement insulates so well: A sliced-through section of set cement reveals the secret: dead air space in the thousands of closely-packed bubbles of alumina.

CARBORUNDUM
Registered Trade Mark

ALFRAX® castable aluminum oxide cements are just about the most effective insulating materials you can find for temperatures up to 3100°F—and especially so at the upper end of the temperature range. They consist of tiny bubbles of pure alumina held together by a bonding agent.

These castables make ideal back-up linings for nonferrous crucible furnaces and for the sidewalls of reverberatory furnaces. Or you can cast them into burner blocks for core ovens and malleable annealing furnaces. Aluminum oxide is one of the most stable and inert of all materials . . . is highly resistant to practically all furnace conditions. And to use, all you do is mix it with water and pour.

So, if you're looking for a castable insulating material to stand really high operating temperatures . . . and keep on standing them through a long, useful life . . . you can end your search right now by writing us for free engineering information on these highly refractory, low heat capacity, easy-to-use cements. Address Refractories Division, The Carborundum Company, Perth Amboy, N. J., Department V85.8

4-point service

Westinghouse, manufacturer of gas, oil and electric heat-treating furnaces, offers an expanded and comprehensive service to help you get maximum speed, quality and dollar savings from your heat-treating operation. The savings realized stem from Westinghouse ideas, know-how and manufacturing capacity.

In scope, this service ranges from unbiased recommendations of fuel, equipment and control devices through manufacturing, packaged installation and proper maintenance of your heat-treating system.

Call your nearest Westinghouse sales office for complete information . . . ask for *The Man With The Facts* on industrial heat-treating.

Les Gillette, Sales and Order Service Mgr., Westinghouse Industrial Heating Division, explains how this exclusive service brings greater economy to your heat-treating operation.

Westinghouse engineers study your plant arrangement, talk to company engineers and dig into every phase of your heat-treating picture. With unbiased recommendations, these Westinghouse specialists often point out new techniques that could improve operations.

Unique production line techniques permit close quality checks on furnace manufacturer from point of initial materials through final assembly and testing. Above is one in-line assembly and testing area in the Westinghouse Meadville plant.

gives you more heat-treating per dollar . . .

1. Engineering consultation and recommendations—Westinghouse engineers, experienced in all phases of heat-treating, thoroughly analyze your problems firsthand. They'll talk things over with your engineers, then make unbiased recommendations as to type of basic and auxiliary equipment most suitable for your needs.

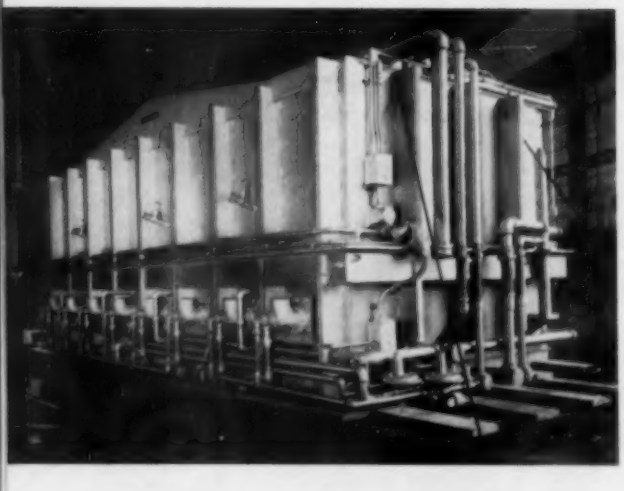
2. Skillful equipment design—Most of our design engineers have at least 14 years' experience in the erection, operation and maintenance of industrial furnaces. This background of factory and field know-how makes advanced and skillful furnace design the rule at Westinghouse . . . design that assures heat-treating to highest quality, speed and economy standards.

3. Quality manufacturing techniques—Furnaces tailored to your requirements are manufactured entirely within the Westinghouse plant on a production line procedure. This means close quality checks, by experts, during every step of assembly . . . means packaged equipment and pinpointed responsibility.

4. Unique packaged installation — Installation of completed equipment is done in one quick operation. Everything is shipped intact . . . no assembly work required in your plant. Westinghouse installation teams are thorough and efficient. What's more, Westinghouse engineers establish maintenance procedure for you and check back periodically to assure peak efficiency from equipment. J-10438

YOU CAN BE **SURE**...IF IT'S

Westinghouse



Westinghouse ships erected furnace sections with parts fitted and matched. This pre-packaged shipment saves you storage and handling problems. Westinghouse will supervise or undertake complete furnace erection and installation, thereby assuring peak operating efficiency.

Put this service to work for you! For more information, mail this coupon or call your nearest Westinghouse Sales Office.

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☐ Please have your representative call

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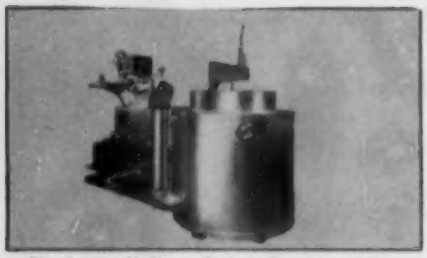
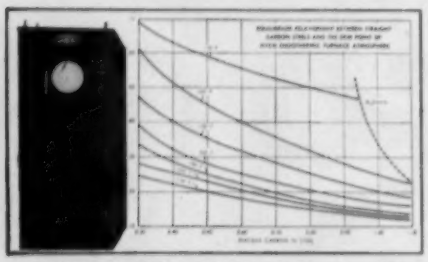
HERE AT LINDBERG WE'RE GETTING YOU ABOUT A GREAT NEW FURNACE



The famous Lindberg Cyclone Furnace has been reducing costs and improving quality of tempering, annealing, nitriding, stress-relieving and nonferrous heat treating for 20 years.



Lindberg dew-point equilibrium curves accurately determine carbon potential in endothermic atmospheres and Lindberg Carbotrol unit controls these values automatically.

The Lindberg vertical radiant tube is only 59 in. long, weighs only 29 lbs. Easy to change. Exclusive "dimple" design insures combustion over length of tube.

There's real furnace news coming from Lindberg.

When metal needs heat Lindberg, over the years, has consistently pioneered better ways to apply it. A revolutionary new development to be announced in September climaxes a long list of Lindberg firsts.

In 1935 Lindberg's famous Cyclone furnace replaced radiation convection with high speed 100% forced convection.

The world's first high temperature (2200° F.) Hyen (endothermic) gas generator was introduced in 1942.

1943 saw 100% high speed convection pushed up into the high temperature field (1750° F.).

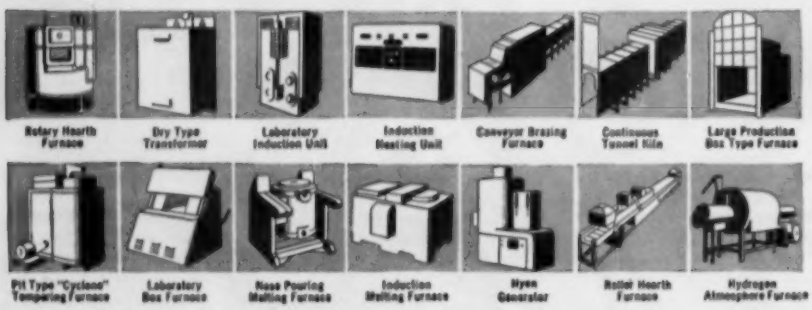
The introduction of the two-chamber aluminum induction melting furnace came in 1947.

In 1948 Lindberg developed the first high frequency method for measuring carbon and sulphur in steel.

An enamel-coated alloy, vertical radiant tube, providing fast heat release in relatively short length for carbonitriding and carburizing, was brought out in 1953.

In 1954 Lindberg released the first comprehensive set of dew-point equilibrium curves to determine accurately carbon potential in endothermic atmospheres and also introduced the Lindberg Carbotrol unit to control these values automatically.

You can continue to look to Lindberg for the improvement of the processes of applying heat industrially. Particularly, watch for the announcement next month of one of the most revolutionary developments ever made in the furnace field.



Lindberg manufactures many kinds of equipment in the industrial heating and related fields. A few of these are symbolized here. If you are interested in any of these, please write us for the specifics on them, or get in touch with your nearest Lindberg Field Engineer. (See your classified telephone book.)

Associate Companies: Lindberg Industrial Corp., Chicago • EFCO-Lindberg, Ltd., Montreal • Lindberg Italiana, Milan • The Electric Furnace

READY TO TELL DEVELOPMENT!

Here at Lindberg, engineers and technicians have been working for months on a development that we believe is one of the most important in the industrial furnace field. We can't tell you all about it until September but we are so sure that it is important news to everyone working with metal that we are giving this advance notice of what's coming from Lindberg. Look for the announcement in September trade papers or, if you're in Chicago September 6 to 16 for the big shows, arrange to see this development at one of the special showings in our plant.

We are planning a series of showings of this new development at our plant during the period of the three Chicago Shows, September 6 to 16. If you are in Chicago, phone MOnroe 6-3443 and we'll make arrangements for your attendance at one of these showings.

LINDBERG ENGINEERING COMPANY

2448 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 Regentview Ave., at Downey, California

Company, Ltd., Weybridge, Surrey, England • Etablissements Jean Aubé, Paris • Lindberg Industrie Ofenbau, Gross Auheim, Germany

SODIUM
metallic

talk about reducing!

—and you'll talk about Ethyl's high purity sodium. Ethyl Corporation, working closely with organizations in the chemical and metallurgical fields, offers metallic sodium ideally suited in form and purity to the needs of those interested in reducing metal salts or in other reactions with organic and inorganic compounds.

Available in tank cars, and cast solid in drums, Ethyl can furnish sodium specially filtered and handled under argon, out of contact with nitrogen or oxygen.

Top physical properties of the refractory metals demand the finest sodium. Numerous chemical reactions may benefit greatly from the use of this high purity sodium.

The Ethyl Research Laboratories have developed improved techniques for the analysis of sodium for oxides and other impurities. We would be happy to supply high purity sodium for your work and to give technical service on sodium analysis where desired.

ETHYL SODIUM METALLIC ETHYL CORPORATION

Chemicals for industry

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High Temperature Furnaces

FOR CARBIDES, HOT PRESSING AND GRAPHITIZATION

Whether you manufacture carbides on a production line basis, or conduct high temperature studies in the laboratory, Ajax-Northrup equipment provides the ideal answer for your heating requirements. Fast efficient heat . . . at temperatures from 1200° to 2600°C and above . . . with negligible heat loss to surroundings . . . are all advantages that only Ajax-Northrup high temperature furnaces afford.

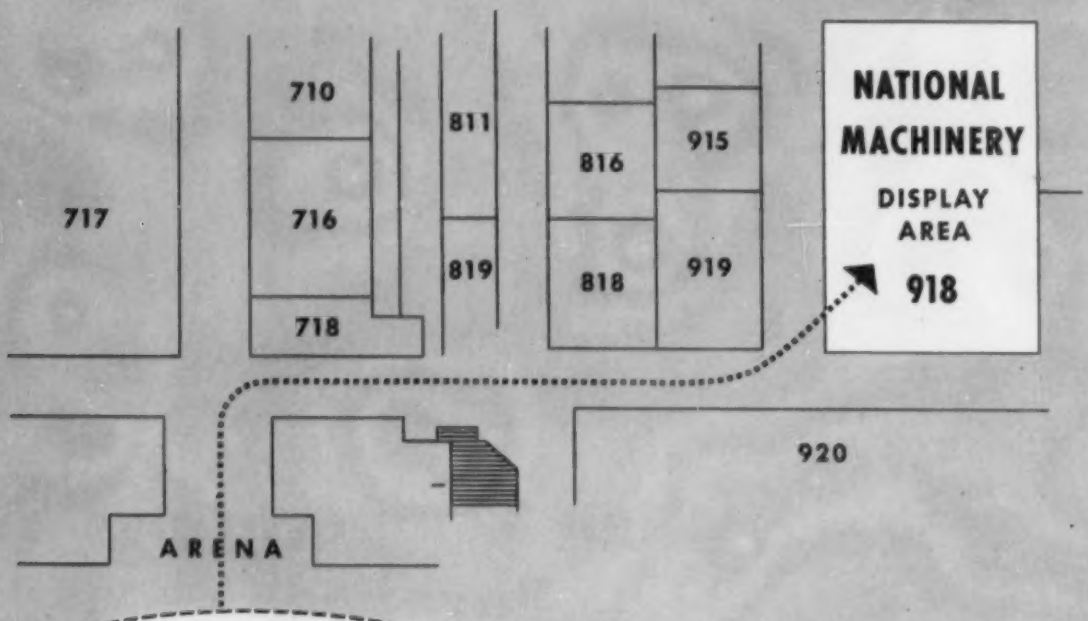
Ajax provides a variety of special furnaces for carbide manufacture and high temperature research. Essentially these are skeleton type furnaces operated by motor generators or high-frequency converters.

Carbide furnaces are usually equipped with Acheson graphite crucibles or sleeves which are good conductors of electricity and capable of attaining high temperatures. For hot pressing of carbides, either graphite or oxide refractory sleeves are employed and the furnaces may be used with either vertical or horizontal presses. For details, write Ajax Electrothermic Corporation, Trenton 5, New Jersey.

Associated Companies: Ajax Electric Company — Ajax Electric Furnace Co. — Ajax Engineering Corp.

AJAX NORTHRUP SINCE 1916

INDUCTION HEATING-MELTING



DISPLAY AREA 918 . . . PROGRESS IN FORGING

AT THE MACHINE TOOL SHOW,

CHICAGO, SEPTEMBER 6 TO 17!

We at National Machinery, WHQ*
for the development of advanced methods
and machinery for the forging industry,
for more economically producing
a wide variety of parts—
routine or unusual, ferrous or non-ferrous,
automatic or semi-automatic,
by cold forging or hot forging—
invite you to visit our working exhibit
at the coming machine tool show,
the first in seven years!

*WORLD HEADQUARTERS

NATIONAL
MACHINERY COMPANY
TIFFIN, OHIO—SINCE 1874

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES • MAXIPRESSES • REDUCEROLLS • COLD HEADERS • BOLTMAKERS • NUT FORMERS • TAPPERS • NAILMAKERS

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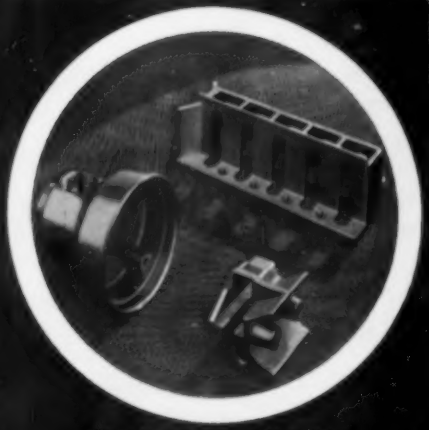
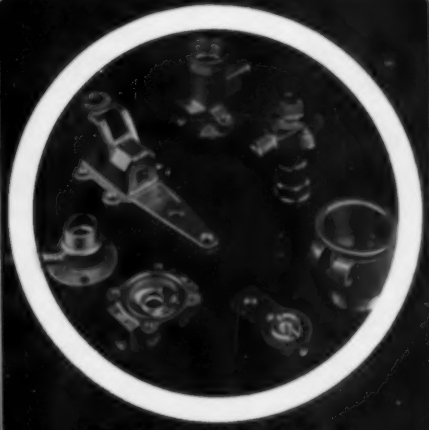


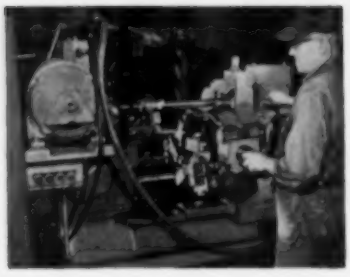
Titan brass pressure die castings



Titan brass and bronze forgings

Titan brass and aluminum hand screw machine parts

One of Titan's modern automatic chucking machines for preparing brass and aluminum forgings to customer specifications. Titan performs all types of machining operations.



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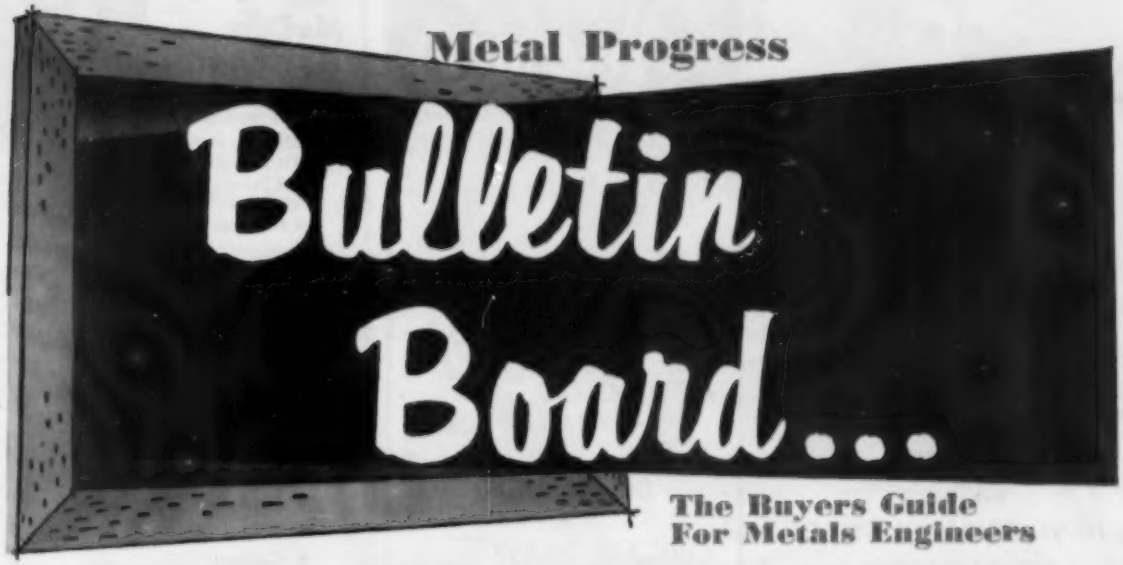

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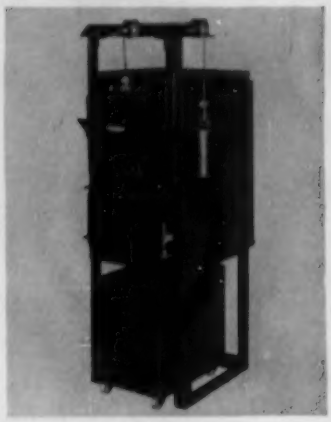
2 FOR 1



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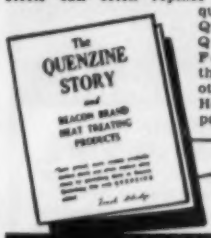

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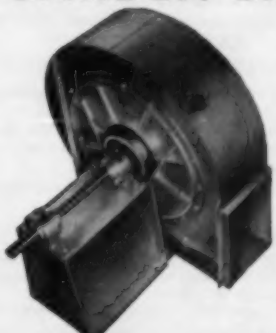

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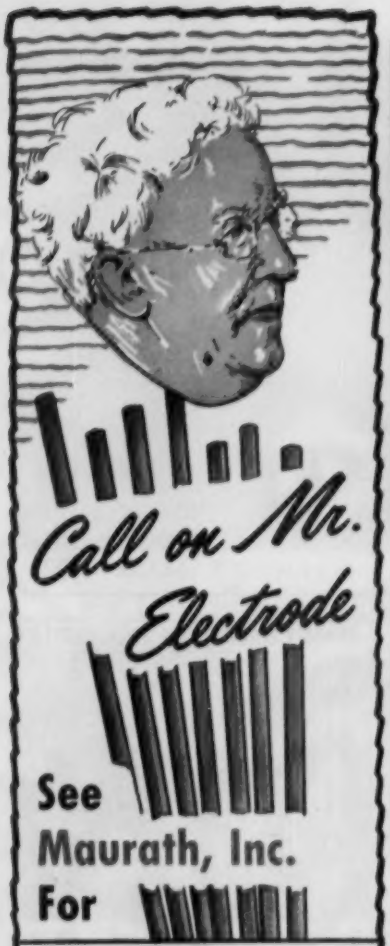

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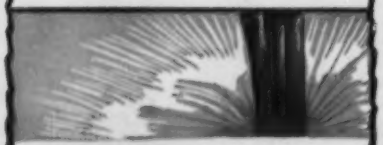

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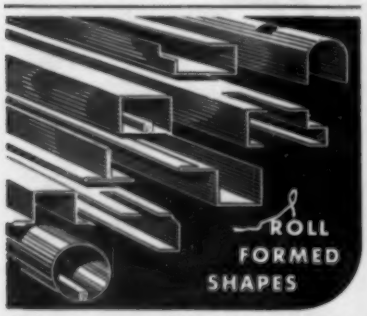

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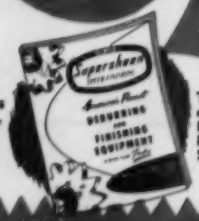

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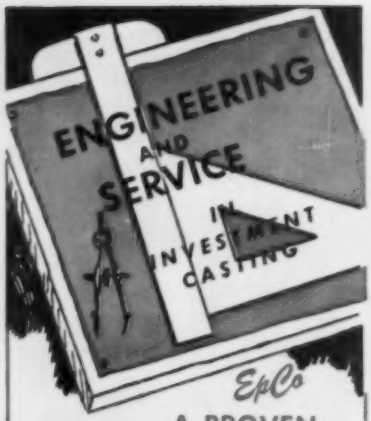

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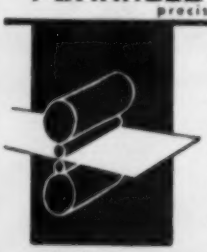

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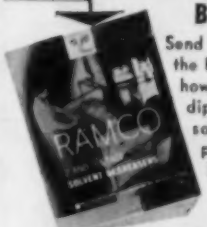

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1375 Lafayette Ave., New York 39, N. Y.

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MANHATTAN

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Foundry Snagging—Billet Surfacing—Centerless Grinding

Cutting and Surfacing concrete granite, and marble

"Moldiscs" for rotary sanders

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Bearing Race Grinding and Finishing

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MANHATTAN RUBBER DIVISION
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BEL-RAY has pioneered in the manufacture of special lubricants to meet the many difficult lubricating problems of industry. Write us for information which will assist you in choosing the correct lubricant for *YOUR* requirements.

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- Non-Melting Greases
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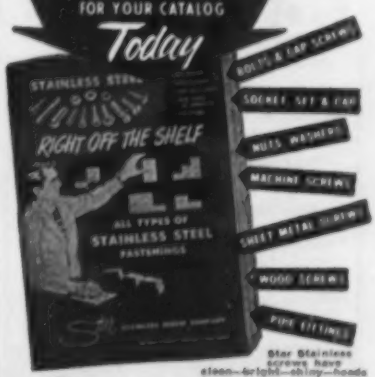
WRITE, WIRE or PHONE FOR YOUR CATALOG Today



Star Stainless screws have clean—bright—shiny—heads

STAR STAINLESS SCREW CO.

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foolproof bond
for any product finish
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PHOSPRAY

a cold spray bonding solution applied with ordinary spray equipment.

SAVES EXCESSIVE HANDLING TIME REQUIRED BY HEATED PHOSPHATE PROCESSES.

Phospray minimizes cleaning and eliminates rinsing and drying.

Phospray dries "dust free" immediately, ready for application of final finish.

Phospray can be cut with thinner as high as 3 to 1 without reducing effectiveness.

Phospray has been thoroughly field tested to govt. specs.

Phospray cuts processing time, reduces finishing costs, and provides an easy sure-fire bond for organic finishes on almost any metal.

Phospray is made and guaranteed by Du-Lite, the metal finishing specialists.

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Du-Lite
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HOW TO DO BRIGHT GOLD PLATING *without scratch brushing or buffing!*

GOLD
SILVER
RHODIUM

Write for complete details

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BRIGHT GOLD PROCESS
FOR INDUSTRIAL and DECORATIVE USES

1. Exceptionally hard deposits — twice the hardness of conventional gold plating.
2. Operates at room temperature — requires absolute minimum control.
3. Excellent metal distribution and "throwing power."

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SINCE 1923

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Offices and warehouses in principal cities

CIRCO VAPOR DEGREASERS—large or small—automatic or manual operation

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CIRCO-SONIC DEGREASERS — newest development—cleaning by *ultrasonic* vibration

CIRCO-SOLV (Trichlorethylene) and PER-SOLV (Perchlorethylene) — high purity, low-cost solvents

FREE! Write for 32-page CIRCO Degreasing Manual

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BASKETS for all industrial requirements

for de-greasing — pickling
anodizing — plating
materials handling
small-parts storage

of any size and shape — any ductile metal

by THE C. O. JELLIFF MFG. CORP.
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WIRE PRODUCTS Jelliff SINCE - 1880

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WHITELIGHT
MAGNESIUM
your comprehensive independent source of magnesium alloy
Tubes • Rods • Shapes • Bars
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INDUSTRIAL PROTECTOX applies invisible tarnish-resistant coating—0.0000005" thick—on all surfaces of silver, silver alloy, copper, brass and gold. Applied by simple two-step process, protects surfaces against tarnish in open trays, in storage, in shipment—renders them resistant to sulphur fumes, other industrial atmospheres. Excellent base for lacquer, improving lacquer adherence by 300%. *Protectox* treated surfaces easily soldered; treated contacts may be built into relays or other equipment without pre-treatments. Film has low specific resistance, is removed by first operation of contact except in very low level circuits. Also removed by rosin flux and soldering heat without pre-treatment and by abrasion, rubbing, or prolonged handling. Product of Technic, Inc., originator of scientific electroplating of precious metals and supplier of plating solutions—largest enterprise of its kind in the world. Write for "Industrial Protectox" Data Sheet—full details, application procedures, costs, etc. TECHNIC, INC., 39 Snow Street, Providence, Rhode Island.

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at the
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October 17 to 21
in
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Grade "B"
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METAL PROCESSING
Eliminates . . .
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Write for free sample and brochure
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USE SWIFT BLACK!
For efficient metal cleaning
USE SWIFT CLEANING COMPOUNDS!
For certain rust prevention
USE SWIFT RUST PREVENTATIVES!
For heat treating
USE SWIFT SALT BATH!
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USE SWIFT QUENCHING OILS!
Send TODAY for descriptive literature and technical data sheets.
See us at Booth 1975,
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Swift
INDUSTRIAL CHEMICAL CO.
Canton Connecticut

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ENGINEERING ALLOYS
by N. E. Woldman

This up-to-the-minute book lists over 19,000 alloys by trade name and gives their properties, compositions and typical applications. All important commercial alloys are shown.

1056 pages of valuable information, generous index and tables of manufacturers and the trade names of their products.

Price, $15.00

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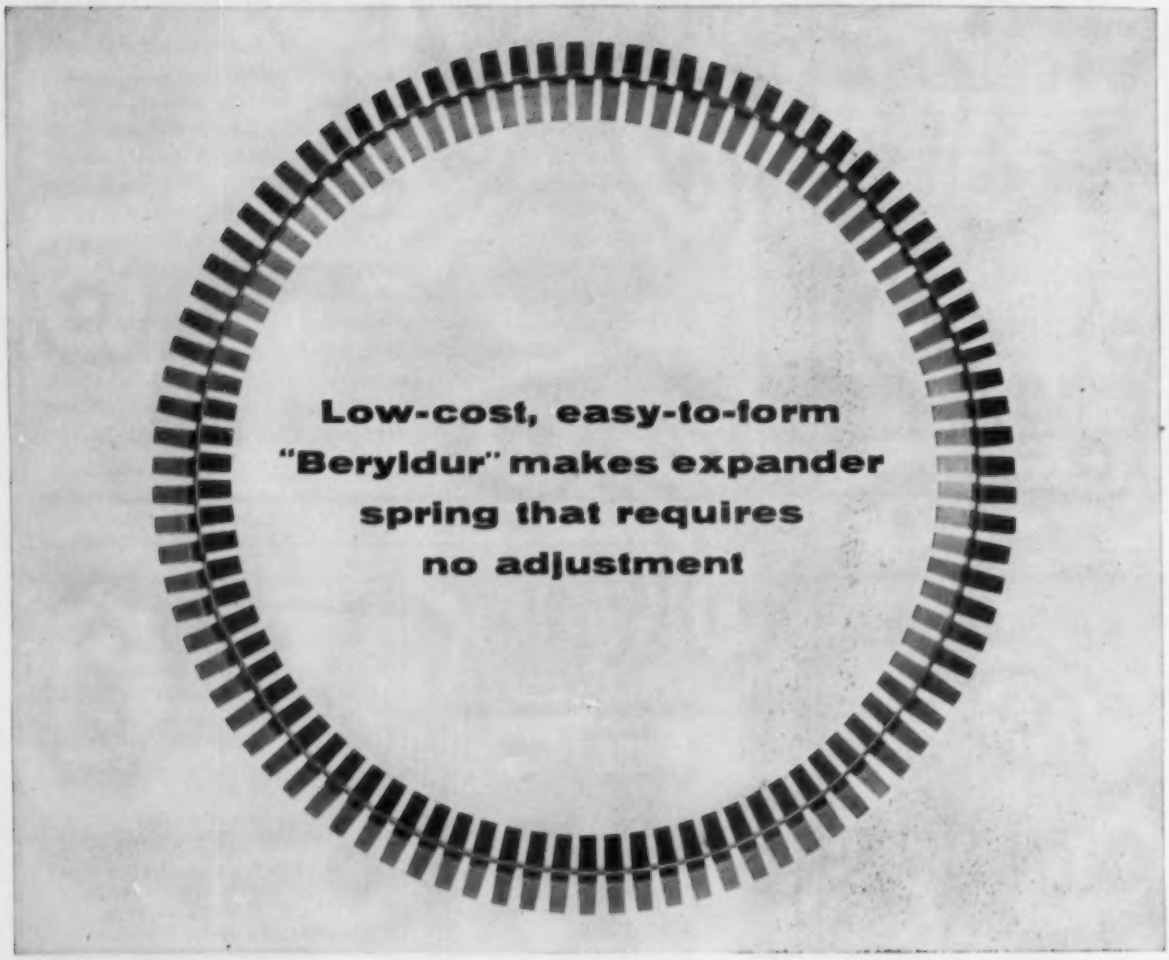

This finger spring is a U packing expander which maintains a seal at 0-5 pounds in the cylinder of a hoist.* What are the characteristics demanded in an application of this kind? First, corrosion resistance. "Beryldur," like all beryllium copper alloys, is highly corrosion resistant. Second, uniform spring pressure. If the expander is too loose, the packing will leak oil and water. If it is too tight, it will prevent the plunger from moving freely. It is enough to say on this point that this "Beryldur" expander never needs field adjustment.

Finally, formability is all-important. The 130° bends parallel to the rolling direction around a 1/16" radius could cause trouble—but in "Beryldur," grain direction is uniform and blanking is no problem. The expander was originally made of 12 6-in. sections riveted together; now it is made of two strips of mill-hardened "Beryldur."

The properties of "Beryldur" are midway between those of high-strength and high-conductivity "Berylco" Beryllium Copper alloys. "Beryldur" therefore has a higher tensile strength than brass or bronze, plus high fatigue strength, great resistance to wear, and good electrical conductivity. For sample material or engineering help, call or write any of the offices listed below.

*Made by Globe Hoist Co., Des Moines, Iowa, Philadelphia, Pa.

"BERYLDUR" EXPANDER is pushed down over plunger, then U packing is forced over the expander.

FURTHER INFORMATION about "Beryldur" is contained in this 4-page folder. Send for your free copy today.

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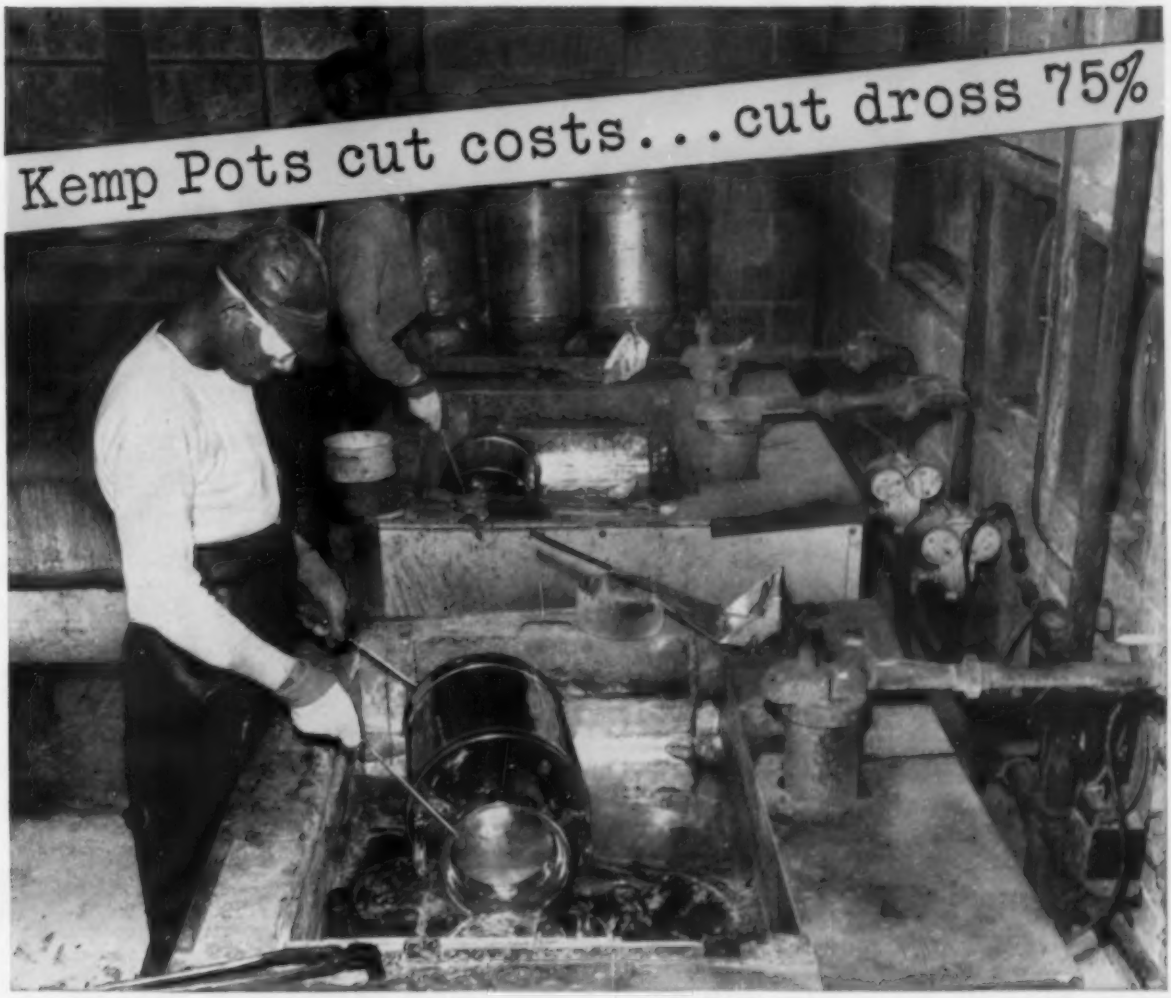


Springfield Can Co. reports: *Improved retinning quality at lower cost with Kemp Melting Pots*

Retinning dairy equipment is the main plant operation at the Springfield (Missouri) Can Co. Milk cans are treated in a retinning room where 2 Kemp Immersion Heating Pots melt block tin and keep it in liquid form for the operation.

Installed in January, 1955, the Kemp Pots have already proved superior to the old, externally heated pots in quality control. They have reduced dross formation 75%. The constant, even heat of Kemp Pots helps produce heavier tin coatings, which give the retinned cans the quality appearance and life of new cans.

Kemp Saves Fuel, Production Time

The Kemp units heat much faster than old-fashioned methods and maintain an even temperature. This means lower fuel costs as well as valuable production time saved. Mr. Jack Simon, Springfield Can Co. owner, sums it up by saying, "The Kemp Melting Pot is the finest produced!"

Kemp Can Help You

You benefit in many ways when you install Kemp Melting Pots: they are not subject to periodic and expensive breakdowns . . . offer greater heating surface, faster heat recovery, lower dross formation, even lower room temperatures—they operate continuously at maximum efficiency with a substantial saving in fuel costs.

Find out how Kemp engineers can provide the most profitable solution to your heating or melting problem. Write for Bulletin IE-10 today.

KEMP OF BALTIMORE

IMMERSION MELTING POTS

CARBURETORS • BURNERS • FIRECHECKS • ATMOSPHERE & INERT GAS GENERATORS • ADSORPTIVE DRYERS SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland

From Vacuum Melting—improved alloys with exceptional properties

. . . *greater* UNIFORMITY, *for example*

Vacuum-melted metals introduce a new standard of uniformity. For the nonmetallic inclusions that limit an alloy's optimum performance are almost entirely eliminated. Result: higher production and inspection yields . . . improved fabrication characteristics . . . better electrical conductivity . . . greater physical uniformity.

High-vacuum melting literally sucks gaseous impurities from the molten metal . . . makes possible high-purity metals with properties unattainable by any other commercial method. Jet engine turbine blades give more than *twice* the performance life of similar blades of conventional air-melted alloys. And here's another example—rejections of high-speed, heavily loaded bearings dropped from 50% to 3% when vacuum-melted metals were used.

Now, you can get these unique new metals for your applications. For Vacuum Metals Corporation, pioneer in development and leading producer of vacuum-melted metals, has them available in tool, high-speed, stainless and alloy steels—in most sizes and grades—as well as special ferrous and nonferrous alloys. If you have a metals problem that vacuum-melted alloys might solve, please describe it in as much detail as possible. Write *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

If you're eating your heart out over polishing costs---read this!

Skyrocketing enthusiasm of America's homeowners for high-quality solid-brass lighting fixtures created a temporary bottleneck in the polishing room of Globe Lighting Products, Inc., one of the leaders in the field. This production problem coincided with the introduction of Formbrite* to the metal-working industry a couple of years ago.

Globe's acceptance of this easy-to-polish fine-grain drawing brass was immediate and enthusiastic. Results were highly successful from the very beginning. Work pile-ups in the polishing room were eliminated and polishing costs were cut in half on many items (see typical examples below). In addition, Globe learned, as have many others, that Formbrite provides a more lustrous finish—is harder, stronger, springier and more scratch-resistant, yet has remarkable ductility for forming and drawing operations.

Surprisingly, Formbrite doesn't cost a penny more than ordinary drawing brass. Why not pass the good news along to those who head up your engineering, design or production departments? Ask them to write for booklet B-39 . . . or phone for a sales representative . . . or request a free sample of Formbrite to try in your own shop. Address: The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

2580

*Reg. U. S. Pat. Off.

Parts illustrated are approximately three-quarters actual size.

48% saving 5/16 x .062" round-edge Formbrite strip in this scroll eliminated a before-bending polishing operation.

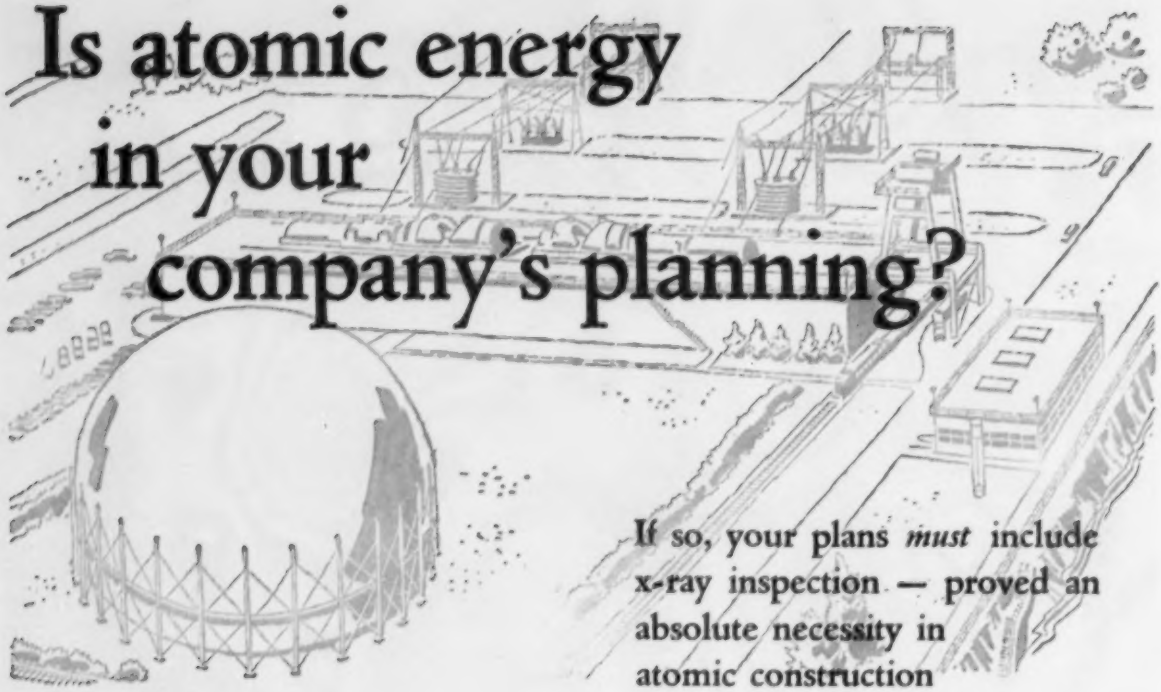
26% saving Tens of thousands of these drawn canopies, socket cups, etc., have been made of time-and-cost-saving Formbrite.

45% saving After forming, this Formbrite channel edging is simply bright dipped, color buffed, degreased, lacquered. That's all!

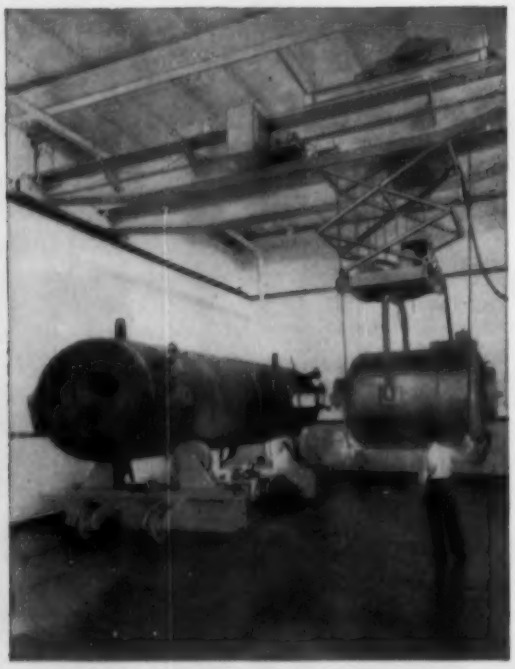
55% saving This hard-to-handle ornamental banding now gets only a simple color buff, saving as much as the cost of the metal.

Formbrite
FINE-GRAIN DRAWING BRASS
an ANACONDA product
made by The American Brass Company

Is atomic energy in your company's planning?



If so, your plans *must* include x-ray inspection — proved an absolute necessity in atomic construction



This 2,000,000-volt Resotron 2000 is typical of General Electric x-ray units now serving the atomic industry.

General Electric is presently supplying more x-ray equipment to atomic energy programs than to any other single industry — with good reason. Here, where failure cannot be tolerated, x-ray inspection is the *only* method which provides visible proof of the soundness of components and materials used in nuclear construction.

With the industry's widest experience in high-voltage x-ray — with more than one hundred super-voltage installations — General Electric is a natural choice whenever x-ray equipment is specified in this fast-growing field.

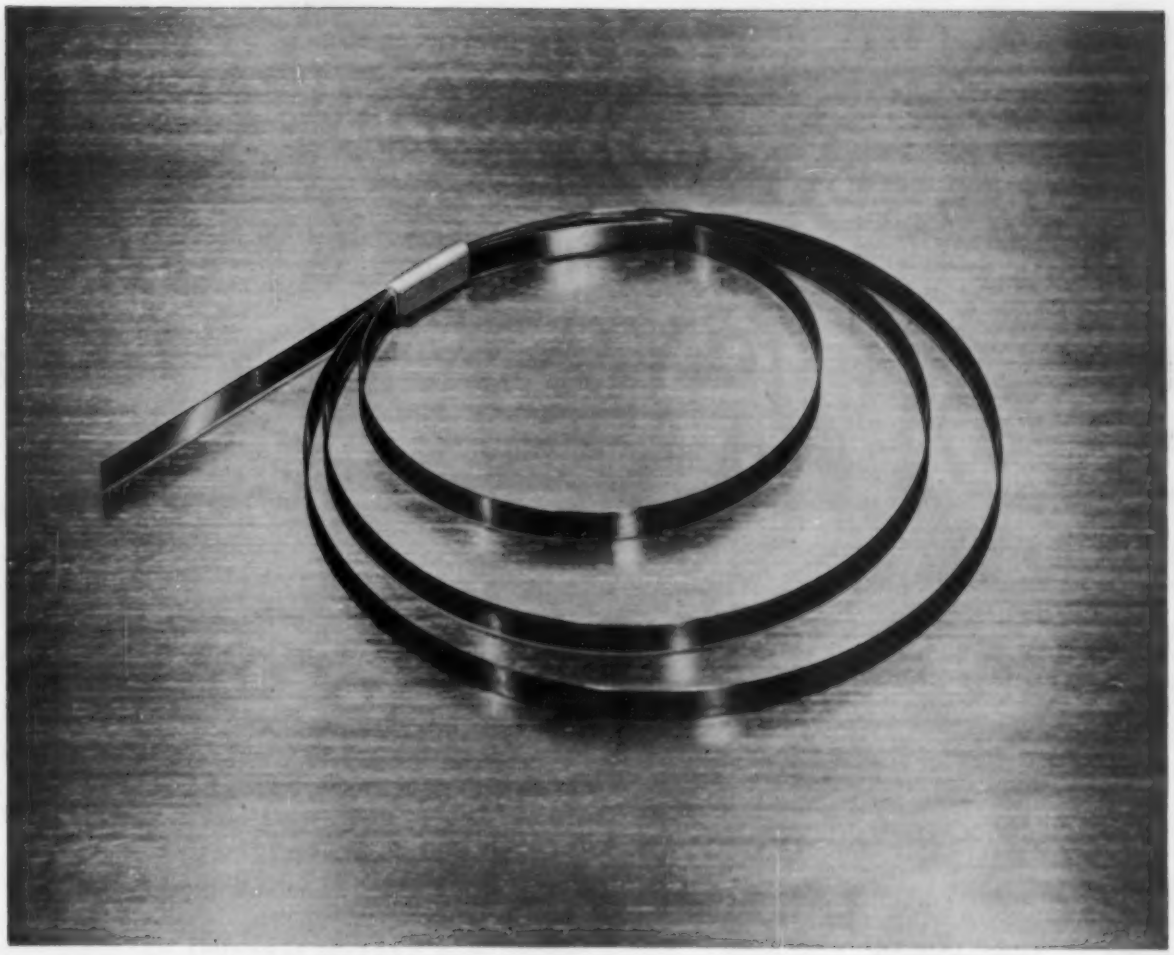
At the very start of your atomic energy planning, consult General Electric for both needed apparatus and necessary application experience. Our representatives are fully prepared to help you work with the atom.

• • •

High-voltage x-ray inspection for quality control is just one of the ways G.E. applies x-ray and related radiation to industry. If you have a non-destructive testing or inspection problem, contact your nearest G-E x-ray representative or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. **AS-84.**

Progress Is Our Most Important Product

GENERAL ELECTRIC



TWO STRIPS OF COLD-ROLLED STEEL?

That's right. The picture above was made from a photograph of two strips of Uddeholm cold-rolled strip steel, both shown here actual size. You see one, ⅛-inch wide, but where is the second? You've probably guessed it: the entire background of the picture is a wide strip of cold-rolled steel.

We took this picture to illustrate the great range of sizes you can get when you order Uddeholm Swedish strip steel.

Widths from ⅛ to 16¼ inches.
Thicknesses from .001 to .125 inches; tolerances as close as ±8/100,000 of an inch.

Stocks of clock spring steel, bandsaw, flapper valve, thickness gauge, razor, and many other types, in many finishes, are carried in New York, Cleveland, and Los Angeles.

WRITE FOR SUBSCRIPTION TO UDDEHOLM'S MONTHLY STOCK LIST OF STRIP STEELS.

UDDEHOLM, 155 East 44th St., New York 17, N. Y.

Please send me monthly strip steels stock list.

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TITLE_____

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UHB

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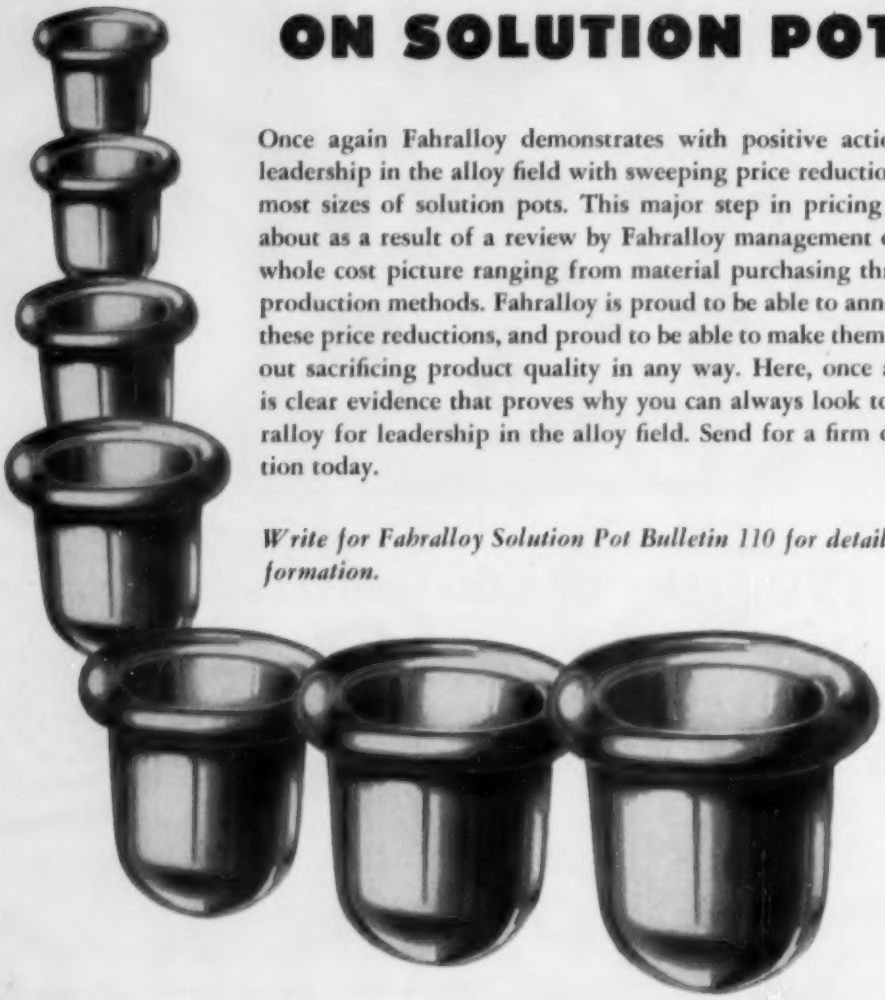
Specialty Strip Steels

New York: 155 East 44th Street, MUrray Hill 7-4575
Cleveland: 3756 Carnegie Avenue, HEnderson 1-7440
Los Angeles: 5037 Telegraph Road, ANgelus 2-5121

THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S

FAHRALLOY...

SETS THE PACE WITH PRICE REDUCTIONS ON SOLUTION POTS



Once again Fahralloy demonstrates with positive action its leadership in the alloy field with sweeping price reductions on most sizes of solution pots. This major step in pricing came about as a result of a review by Fahralloy management of the whole cost picture ranging from material purchasing through production methods. Fahralloy is proud to be able to announce these price reductions, and proud to be able to make them without sacrificing product quality in any way. Here, once again, is clear evidence that proves why you can always look to Fahralloy for leadership in the alloy field. Send for a firm quotation today.

Write for Fahralloy Solution Pot Bulletin 110 for detailed information.

THE FAHRALLOY CO.

150th & Lexington Ave. — Harvey, Illinois

In Canada — Fahralloy Canada, Ltd., Orillia, Ontario

Westinghouse announces . . .

New induction heater designed for easier conversion

Building-block design of the new Westinghouse 30-kw induction heater permits 32 regular combinations for your low-power applications, plus a number of special arrangements. It provides the kind of flexibility and convenience you need to keep abreast of your constantly changing production setups.

Versatile—you get custom-built installation of standardized equipment to handle a wide range of applications. Unit ideal for hardening, annealing, brazing or soldering.

Easy to Use—front of worktable, free of controls, can be used for mounting work-handling equipment. Instruments at eye level for easy readability. M-G set readily accessible without removing panels. Buy the equipment you want, adapt it when your needs change: single to two-station operation—sink to bench top—high-voltage to low-voltage output—grouped as a compact unit to remotely located output stations.

Equipment consists of four basic units: (1) 30-kw, water-cooled, 10,000-cycle M-G set, (2) generator control cabinet, (3) high-frequency output cabinet, (4) work table.

For more information about improving your induction heating operations, call *The Man With The Facts*—your Westinghouse sales engineer. Ask him for your copy of booklet B-6519, or write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 30, Pa. J-02297

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Westinghouse

what's new at BRISTOL...

SERIES 536 INDICATING

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A new development in automatic temperature control

featuring...

● **A UNIQUE ELECTRONIC CONTROL SYSTEM, which gives a new quality of automatic control.** The controller is extremely stable, rugged, and sensitive. Very minute changes in the measured quantity at the control point (less than 0.003" on the scale) closes or opens the Thyratron-operated relay with positive trigger action, making it impossible for the relay to flutter or chatter. Control action is unaffected by changes in ambient temperature, line voltage, or wide variations in tube characteristics.

● **A NEW MILLIVOLTMETER MECHANISM for greater accuracy.** High-torque, rugged, jeweled mechanism has 30 ohm coil, Alnico 5 magnet, a sensitivity of 15 ohms per millivolt. All ranges are critically or over damped.

● **OUTSTANDING MECHANICAL DESIGN for easy installation, interchangeability, and simplified servicing.** All units, including pyrometer unit, electronic control unit, and proportional-input unit are separate. The electronic control and proportional-input units plug in. No routine adjusting or attention needed. Series 536 Indicating Free-Vane Electronic Pyrometer Controllers are available as thermocouple and radiation pyrometers in ranges up to 4000° F. for L, H, LH, HOH, and LNH control and for L and H with proportional input control. Write for Bulletin P1248. The Bristol Company, 106 Bristol Road, Waterbury 20, Connecticut. 3.10

LOOK FOR OUTSTANDING NEW DEVELOPMENTS FROM BRISTOL

BRISTOL

THE DEPENDABLE GUIDEPOST OF INDUSTRY

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

SUCCESSFULLY BRAZED WITH

SILVALOY

LOW TEMPERATURE SILVER BRAZING ALLOY

The Ansul Dry-Eye system exemplifies outstanding efficiency in concept and design. It is a product of Ansul developmental research employing a T-flow principle for maximum drying efficiency and a special indicating element which tells at a glance the approximate moisture content of the refrigerant. It is quick and easy to install—and the cartridge can be replaced when required, in less than a minute. This is an important consideration in refrigeration manufacture and service.

Production of the T-Flo Drier is kept at peak efficiency. Joints are brazed in an induction unit with Silvaloy preforms—a production procedure that assures positive, leakproof assemblies.

Low temperature Silver Brazing is helping to improve results, speed production and lower costs for manufacturers in many fields. Call the Silvaloy Distributor in your area for complete information or technical assistance. ★ ★ ★ ★ ★

Hex nut is Silvaloy brazed on cap which is in turn brazed to steel body. Air cylinder is used to hold spring-loaded parts in place in induction coil.

ANSUL

FREE! SEND FOR 48-PAGE BOOK "A COMPLETE GUIDE TO SUCCESSFUL SILVER BRAZING"

THE SILVALOY DISTRIBUTORS

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THE AMERICAN PLATINUM WORKS

231 NEW JERSEY RAILROAD AVENUE • NEWARK 5, NEW JERSEY

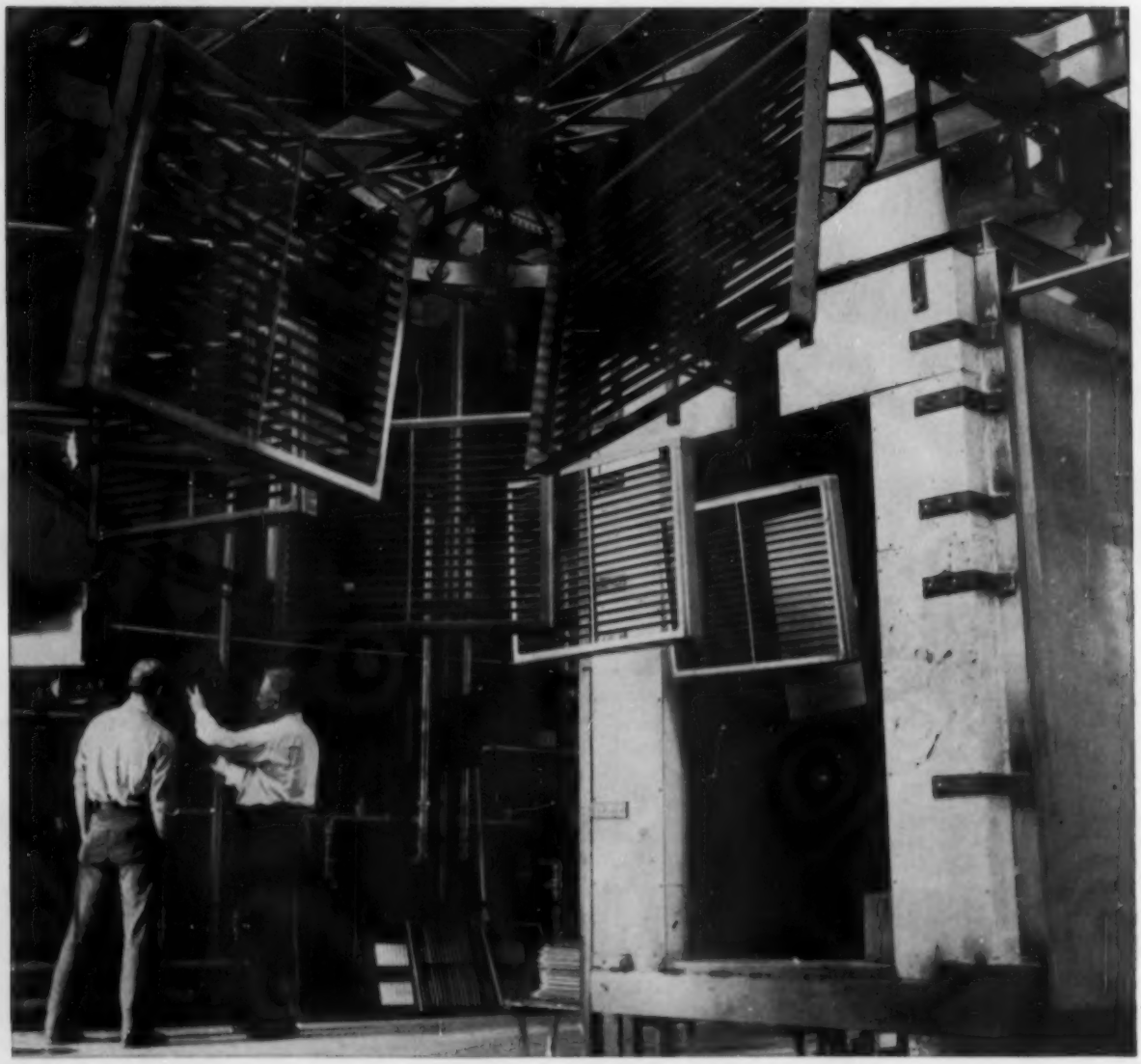
This is a continuous Gas-fired washing, drying and finish baking operation at the Seaboard Metal Products Company in Newark, New Jersey. The company manufactures metal enclosures of all types, as well as related items such as the radiant heating unit covers shown on the conveyor.

The versatility of these Gas-fired units, with a heat input up to five million BTUs, helped owner John Murray convert his shop from a small jobbing to a straight production operation. The units can take any type baking or drying job. Overhead conveyors permit a fast flow of irregular as well as uniform shaped pieces.

Throughout the entire process at Seaboard, Gas is installed as part of the production line. The flexibility of Gas allows close temperature control in a series of chemical baths and rinses preceding the drying and paint-baking process, and without expensive heat-up periods. Gas is this company's choice for fuel because it is faster, cleaner, and keeps operating costs down.

Throughout all industry, Gas is the most satisfactory method of heat processing. That's reason enough for discussing your production problems with your Gas Company's Industrial Specialist. *American Gas Association.*

"*GAS* efficiency speeds our washing, drying and baking process"



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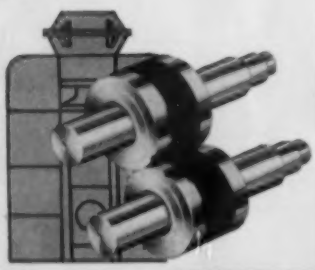

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Metal Progress
Volume 68, No. 2 August 1, 1955

Impact Failure of Gear Teeth

*By ARTHUR J. KAUPER**

Failure of transmission gear teeth was traced to variation in impact strength that followed the ingot pattern in the bar stock from which they were made. (Q6, ST)

SERVICE FAILURES of gears are usually due to wear, pitting or some other types of fatigue failure. All of these are normally associated with long service and can be traced to overloading, inadequate lubrication, improper alloy selection, heat treatment or poor design. Occasionally failures occur that cannot be ascribed to any of these standard causes and that resemble impact failures.

Recently transmission gear teeth were breaking after short periods of service due to extremely severe shifting conditions. Shifting into second, third and fourth gears was done at wide-open carburetor throttle with little or no clutch release. This procedure was used to give the operator the most rapid acceleration possible. The unusual shifting method, coupled with the fact that the fractured surfaces of the broken teeth did not exhibit the characteristics of a fatigue failure, led to the conclusion that the gear teeth were breaking off due to impact loads.

The transmission is a four-speed constant-mesh gear type. Shifting is accomplished by sliding a gear, splined to its shaft, from a neutral position toward an adjacent gear to engage a set of lugs in matching lug sockets. The sliding gears have four lugs on one side and four lug sockets on the other side. Adjacent gears are designed to mesh. The ten diametral pitch gear teeth are machine cut and shaved before heat

*Chief Development Engineer, Harley-Davidson Motor Co., Milwaukee, Wis.

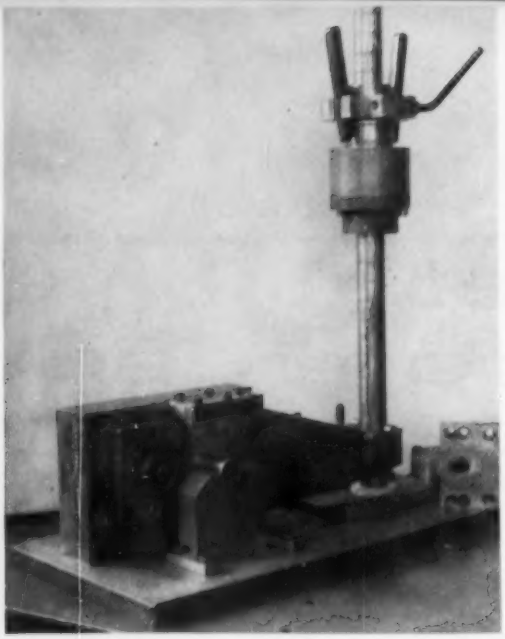


Fig. 1 – View of Test Fixture Used to Determine Impact Strength of Gear Teeth

treating with no subsequent finishing. The gears were made of round, cold finished steel, A.I.S.I. 8617, and were carburized 0.030 in. deep. The hardness of the surface is C-59 to 62 and the core is C-30 to 40. The broad range in core hardness has proved acceptable in service.

A fixture was built which would subject the gear teeth to impact loads (Fig. 1). The fixture has two pilots spaced the same as the spacing of the transmission shafts. These pilots are rigidly supported by the fixture base. The test gear fits on one of the pilots and slips into a nest which engages most of the teeth of the gear. A fixture gear is made of toolsteel with the proper gear tooth profile but the gear teeth are wider and thicker than normal to make it more durable. This fixture gear fits on the other pilot and slips into a nest on a rigid lever arm which is free to rotate around the pilot. Only one tooth on the fixture gear contacts the test gear.

A 15-lb. weight is free to slide on a rigid vertical post. An adjustable release mechanism on the post permits dropping the weight from any desired height. The lever is forked to straddle the post. The weight drops on two hardened contact points on the lever arm which are 1 ft. from the centerline of the pilot about which they rotate. When the fixture gear tooth is brought in contact with the test gear tooth, the point of contact between the two teeth, the lever contact points, and the centerline of both pilots lie on the same horizontal plane.

The test gear is prepared by removing one tooth to provide clearance for the heavier fixture gear tooth. The remaining teeth are numbered consecutively. The gear is assembled in the fixture and the weight is dropped from a height which is known not to cause failure. The weight is dropped several times but each time it is dropped 1 in. more than on the previous drop. After each drop the tooth is inspected. When failure is observed, the test on that tooth is completed and the next tooth is tested. The final height from which the weight was dropped is used as a measurement of the impact strength of the tooth. Each tooth that breaks has at least as many impact blows as any tooth that breaks at a lower value on that same gear, and the final drop gives a comparable measure of impact resistance.

The gears which failed in service have four lug sockets. These create a shallow section under some teeth and a heavier section under the remaining teeth, as shown in Fig. 2. In quenching, the teeth near the shallow sections cooled faster than those in the heavy sections. To determine whether this caused the difference in impact strength several gears were tested. All tests were started with the identical tooth on each gear relative to the geometry of the gear. Representative results for two gears are shown in Fig. 3. These were 24-tooth gears but only 21

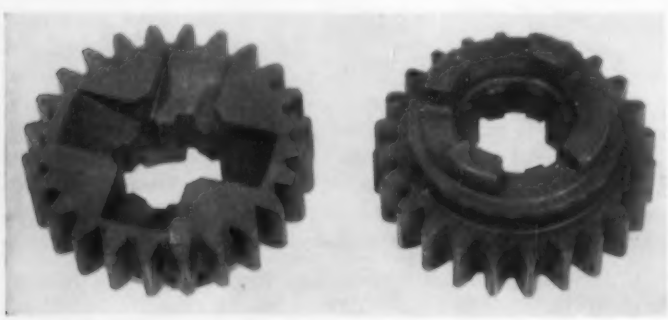


Fig. 2 – Transmission Gear (Two Views) Showing Variation in Section Below Teeth

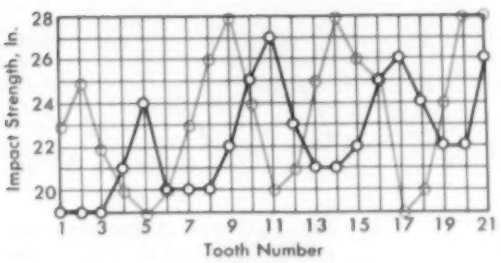


Fig. 3 – Impact Strength of Successive Gear Teeth on Bar Stock Gears

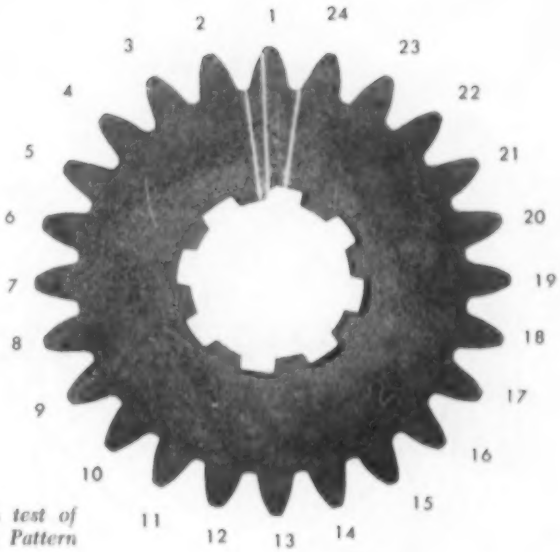


Fig. 4 – Macro-Etch test of Gear Showing Ingot Pattern

teeth were tested. The results of the tests are remarkable for two reasons. First, the plotted curves of the impact strengths of successive gear teeth simulate a sine wave with regularly spaced regions of high and low tooth strengths. Second, the fixture and method of breaking the teeth provide a way to reveal such a trend. The variation in strength, however, could not be attributed to the section size since the strength curves of the two gears are out of phase with each other.

In an effort to determine a reason for this trend, micrographs were made of teeth with high and low impact strength. These showed no apparent variation in structure and the structures appeared to be satisfactory.

An experiment was carried out to determine if the ingot pattern affected the strength of the gear tooth. Ingot pattern generally results from differential etching of columnar and granular structures of the ingot and is almost entirely a result of original ingot solidification. A bar of steel was marked so that when gear blanks were cut from it, their orientation in the original bar could be determined. A disk was cut from each end of this bar and was macro-etched. The disks showed an ingot pattern and there was no rotation of the pattern from end to end of the bar. Gears were made so that the teeth on each gear held the same relationship to the alignment marks. These gears were left with flat sides so that heat treatment would have no differential effect. One of the macro-etched gears is shown in Fig. 4. The relationship between the gear tooth and the ingot pattern is evident.

The test was started with a gear tooth in a different quarter of each gear. The impact strengths of identically numbered gear teeth

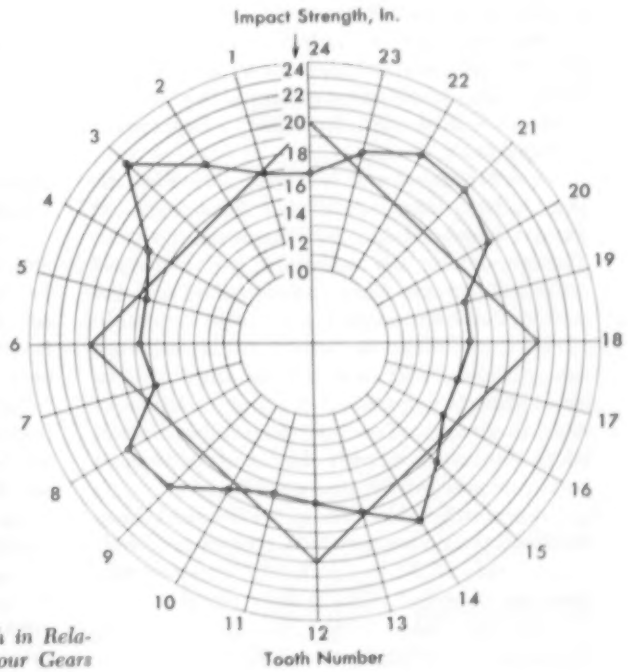


Fig. 5 – Impact Strength of Successive Teeth in Relation to Square Ingot Pattern; Average of Four Gears

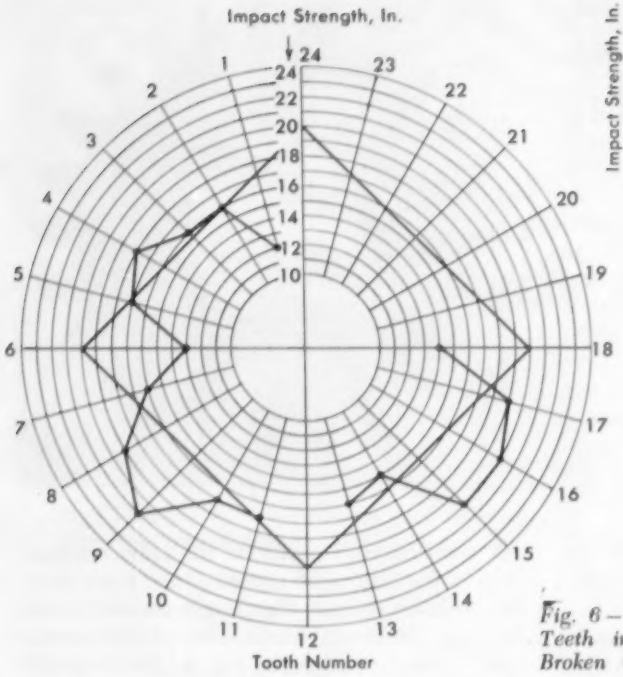


Fig. 6 – Impact Strength of Successive Teeth in Relation to Ingot Pattern; Broken Gear Returned From Service

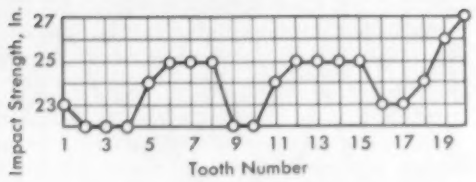


Fig. 7 – Impact Strength of Successive Teeth on a Forged Gear

were averaged and plotted on circular coordinates, Fig. 5. There is no size relationship between the square representing the ingot pattern and the plotted impact strengths. Gear tooth 24 occurs on the corner of the ingot pattern and is plotted accordingly.

Impact strength of the teeth near the corners of the ingot pattern is low, near the center of the flat sides of the ingot pattern it is high, with a transition in strength from low to high on the teeth between.

A similar experiment was made in which the ingot pattern was so small that it was removed when the splined hole was made in the gear. The strength of the successive gear teeth still exhibited the sine wave characteristic, with the teeth of lowest strength lying on the same radii as the corners of the ingot pattern. This indicated the possibility that it is not the ingot pattern alone that is responsible for the variation in impact strength. Possibly some other factor, which aligns itself with the ingot pattern, is partly, or even wholly accountable.

A gear with a broken tooth returned from service was impact tested on consecutive teeth on each side of the broken tooth. The gear was then macro-etched. The results are shown in Fig. 6. The broken tooth, No. 12, occurred at the corner of the ingot pattern; the impact value of the broken tooth was probably 12 in. or less.

Finally, forged gears were used. Transverse sections of the gears showed good grain flow lines through the tooth section. In spite of this, strength of consecutive teeth exhibited the sine wave characteristic with peak-to-valley differences being much smaller than in the unforged gears, Fig. 7. Note that the peaks are considerably flatter than those obtained with the bar stock gears, Fig. 3. When macro-etched, the forged gears still exhibited the characteristic ingot pattern. Although in general the maximum strength of the forged gears is somewhat less than that of the bar stock gears, the weak teeth on the corner of the ingot pattern of the forged gears (with a minimum impact value of 22 in.) were sufficiently strong to warrant no failures in service. All experimental work ceased with development of a satisfactory gear.

This relationship of impact strength to ingot pattern may be instrumental in explaining unusual breakages such as gear teeth breaking on one gear 90 or 180° apart, or unusual variations in the strength of portions of parts made of bar stock, or symmetrical forgings made of bar stock. Perhaps the result of the investigation will be studied by others in an attempt to explain the reason for the relationship between impact strength and ingot pattern.

Applications of Arc-Cast Molybdenum

*By N. L. DEUBLE**

Molybdenum is currently going into production of magnetron tubes and glass melting furnaces; nearing commercial usage are piercer points for the tubing industry, die-casting dies, ramjet nozzles and gas-turbine parts. (Tgeneral, Mo)

ARC-CAST MOLYBDENUM does not as a rule compete with the powder-metallurgy product. Except for a few heavier sections used in the glass-melting industry, powder-metallurgy molybdenum generally goes into small items such as electronic-tube parts, contacts, heating elements, spot welding tips and metallizing rods. Arc-cast molybdenum is more satisfactory for larger parts, or applications where lower gas content or superior weldability and machinability are needed. Furthermore, molybdenum-base alloys unsuited for powder-metallurgy production can be readily arc-cast.

Present Applications

Magnetron Tubes – Unalloyed arc-cast molybdenum has been adopted by one of the largest electronics companies for relatively heavy parts of high-power magnetrons. Because the arc-cast molybdenum contains less gas, the tubes can be evacuated to the desired pressure in a much shorter time than can tubes made of powder-metallurgy molybdenum. In addition, longer shelf life is reported. With proper machining procedures arc-cast molybdenum is also superior in machinability; as an example, threaded sections have a much cleaner surface than with powder-metallurgy molybdenum. Finally, scrap resulting from cracks on some of the parts machined from arc-cast molybdenum now runs about 5%, as compared to 20% for the same part made from the powder-metallurgy product.

Glass-Melting Furnaces – The glass industry has become a major user of large parts of both arc-cast and powder-metallurgy molybdenum. Its high melting point, high strength at elevated temperatures, good electrical conductivity, resistance to attack by molten glass, and the fact that the small amount of oxide formed is colorless are important advantages of the metal. Surface protection against oxidation is necessary, however, during start-up and for any parts not completely covered by the molten glass. Stirrers and other furnace parts are made from molybdenum, but the principal use is for electrodes. They weigh 20 to 50 lb., and may be either of the plate or rod type. The first significant use of molybdenum electrodes was in 1940; they are now used by at least 25 glass plants. Electric melting of glass gives increased production, improved quality, and longer refractory life, and molybdenum has proved to be the best electrode material available today.

*Manager, Metallurgical Development Div., Climax Molybdenum Co., New York City. Fifth in a series of six articles started last April.

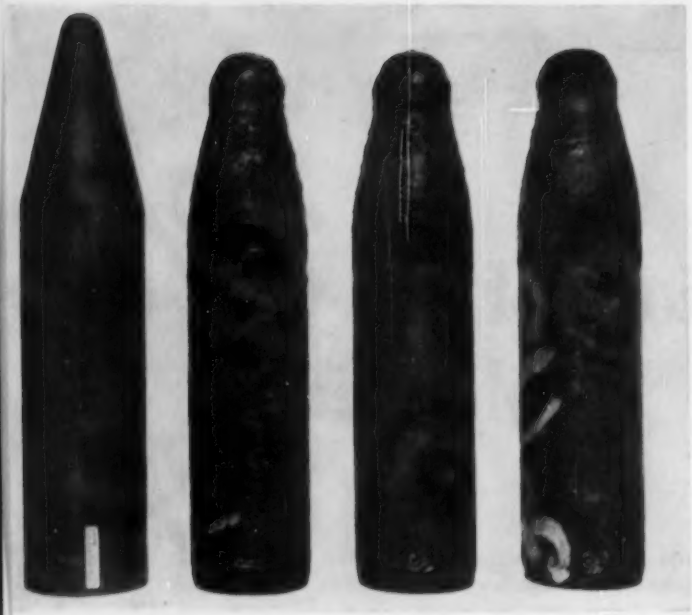


Fig. 19 – Experimental Piercer Points for Production of Seamless Tubes Made of Arc-Cast Molybdenum-Base Alloys. At left is an unused standard point. The next three are made of molybdenum alloy with 1% vanadium and were used without cooling to pierce Type 304 austenitic stainless steel billets, 70¾ in. long. The first pierced 74 pieces before reconditioning; the second, 87 pieces; and the third 110 pieces

Current Development Work

Experimental work to utilize molybdenum's exceedingly high strength at elevated temperature is going forward. Notable among the potential applications are piercer points, die-casting dies, ramjet nozzles and gas-turbine parts.

Piercer Points—Molybdenum-base alloys are showing promise for piercer points to produce stainless and alloy steel seamless tubing, provided they are properly handled. Some comparative tests were made on the piercing of A.I.S.I. 4615 steel, using a molybdenum alloy with 2% tungsten. Ordinarily a regular alloy steel piercer point is quenched in water after each use; 10 to 12 points are used and rotated so a cooled point is available for each billet. A standard point will average about 20 tubes of A.I.S.I. 4615. When the 2% W molybdenum alloy was used, quenching changed the shape of the point to a sphere. Air cooling improved the results slightly but did not prolong the life sufficiently to make the use of molybdenum points economically sound. When cooling was eliminated, however, a single point of molybdenum-base alloy pierced 650 tubes before the pierced hole became too small for the plug on the rerolling mill to enter the cavity for rolling. During this time the point lost approximately ⅜ in. on the diameter by oxidation.

In piercing stainless steel billets, the standard alloy steel piercer point is either reprocessed or scrapped after piercing a single tube. A large tube company had an order that required piercing exceptionally long (about 10-ft.) billets of Types 321 and 347 stainless. Since the usual alloy steel point would not pierce these long billets, the initial hole had to be drilled. Piercer points 2⅜ in. in diameter were then made of the 1% V molybdenum alloy. A small furnace was constructed to hold the point at about 1100° F. between operations to prevent cracks that developed from the nose to the shoulder if the points were allowed to cool down after each use. One of these points was still serviceable after piercing 58 of these 10-ft. billets.

Three points of the same 1% V alloy were later used for production piercing. During a recent run, they pierced 271 billets of Type 304 (about 70¾ in. long) without reconditioning (Fig. 19). In another tube mill, a 2¾-in. diameter point has pierced up to 100 billets of various austenitic stainless steels before reconditioning. These results are considered so outstanding that further work is contemplated to determine if they are reproducible. Molybdenum-base alloys, however, have already been adopted as standard for piercing extra-long stainless steel billets.

Die-Casting Dies – It is almost impossible to produce thermal checks in molybdenum because of its low coefficient of expansion and high thermal conductivity. For this reason, molybdenum offers great possibilities as a die material for brass die casting, where other metals and alloys have uneconomically short lives. Preliminary tests showed that unalloyed molybdenum did not check in 13,000 shots whereas some ferrous alloys checked in 1000 shots, and the best die steel in 3000. Unalloyed molybdenum, however, was not satisfactory because the impression flowed slightly. Additional development work is now under way on the 0.5% Ti and the 1% V alloys, which have greater hot hardness. While it is possible that changes in die design may be needed with the molybdenum-base alloys, it appears probable that, by increasing die life and lowering the unit die cost, they will eventually make the die casting of copper-base alloys competitive.

Ramjet Nozzles – Two or three years ago, one of the aircraft manufacturers designed an experimental molybdenum ramjet nozzle assembly, which weighed only about one-quarter as much as a similar ceramic nozzle. This project was finally abandoned because of welding difficulties, but not before coated specimens of molybdenum had been tested for 6 hr. without failure. This represents a sizable safety factor since the actual service life is only 15 min. Good progress in welding molybdenum for structural purposes has since been made by various companies (Fig. 20), so this consideration should not be such a limiting factor in the future.

Gas-Turbine Parts – The greatest interest in molybdenum-base alloys is for gas-turbine parts, such as guide vanes and buckets (Fig. 21). With their exceedingly high rupture strengths, high modulus of elasticity, low coefficient of expansion, high thermal conductivity and toughness at elevated temperatures, molybdenum-base alloys offer the designer most of his requirements except low density and oxidation resistance. The high density is not too serious because of the metal's high strength and elastic modulus at service temperatures. The development of a wholly satisfactory oxidation resistant coating offers a challenge to the research man; if this problem can be solved, the operating temperature of gas turbines could be increased some 300 to 400° F. A. J. Herzig will discuss this in more detail in the sixth article of this series.

Fig. 20 – 6-In. Diameter Nozzle Arc Welded From Arc-Cast Molybdenum Sheet Has Two Conical Sections and a Flange. Critical dimensions were held by sizing operation after welding. (Curtiss-Wright Corp.)

Fig. 21 – Gas-Turbine Guide Vane Made From 0.040-In. Thick Arc-Cast Molybdenum by Warm Stretch-Forming and Brazing With A.M.S. 4775 Alloy in a Hydrogen Atmosphere. Ends then trimmed, and braze ground and stoned to final contour and dimension. Actual size

The Future

Molybdenum will undoubtedly find extensive and important new uses. The research and development done to date have shown that arc-cast molybdenum and its alloys have inherent characteristics that make them exceedingly attractive to the designer of high-temperature equipment. Industrial utilization of these materials, however, is only in the initial stages. Additional work is needed on problems such as oxidation resistance and welding.

Potential applications outside the elevated-temperature field should be explored; the high modulus of elasticity and resistance to corrosion offer interesting possibilities. Research on new and improved molybdenum-base alloys is being continued. Industrial development programs will not be hampered by shortages. The availability of arc-cast molybdenum and molybdenum-base alloys is limited only by present facilities, which can be readily expanded if necessary; the reserves of molybdenum ore in the U.S.A. are adequate for all projected peacetime demands.

Drawing Failures in Extruded Shells

*By HUBERT J. PESSL**

The cause of a steadily increasing rate of drawing failures of cold extruded 75-mm. shells could not be found until the punch broke. Failure was due to fatigue originating at a "flake". Stresses in drawing had caused the punch to increase in diameter and pinch the shells. (F24, S21, TS)

Typical Failure Encountered in Cold Extrusion of 75-Mm. Shells

IN PRODUCING more than a million 75-mm. shells by cold extrusion of aluminum-killed A.I.S.I. C 1018 steel at the Defense Products Div. of Gibson Refrigerator Co., fractures similar to that shown in Fig. 1 were encountered periodically in the drawing operation.

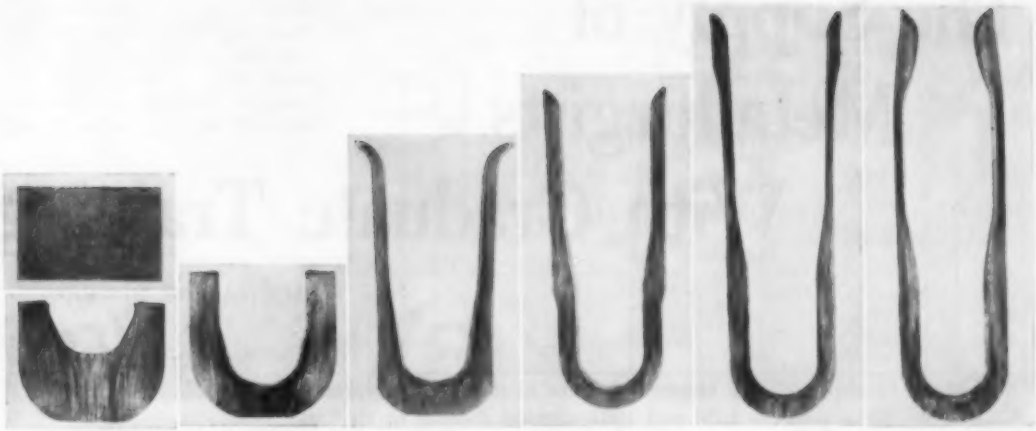
The production sequence is illustrated at the top of the opposite page. The slug is sized prior to being backward extruded. Each of these operations is followed by a process anneal at 1200° F., and a phosphatizing-soap lubrication surface treatment. The part is then forward extruded, coined, drawn and nosed without any further intermediate anneals.

Drawing is severe – 40% reduction in cross section – in order to produce the specified minimum yield strength of 85,000 psi. The draw failures could not be traced to any single variable but were assumed to be caused by a combination of factors: defective steel, faulty heat treatment, surface treatment or tooling.

In one run with a new punch, more than 25,000 shells were produced before the first draw failure. The failures increased in frequency for the next 75,000 shells until the scrap loss was more than 5% of production. Production was stopped and it was decided to add a stress-relieving anneal after forward extrusion.

When the first shell was drawn in the new cycle, the draw punch split completely in two

* Defense Products Div., Gibson Refrigerator Co., Greenville, Mich.

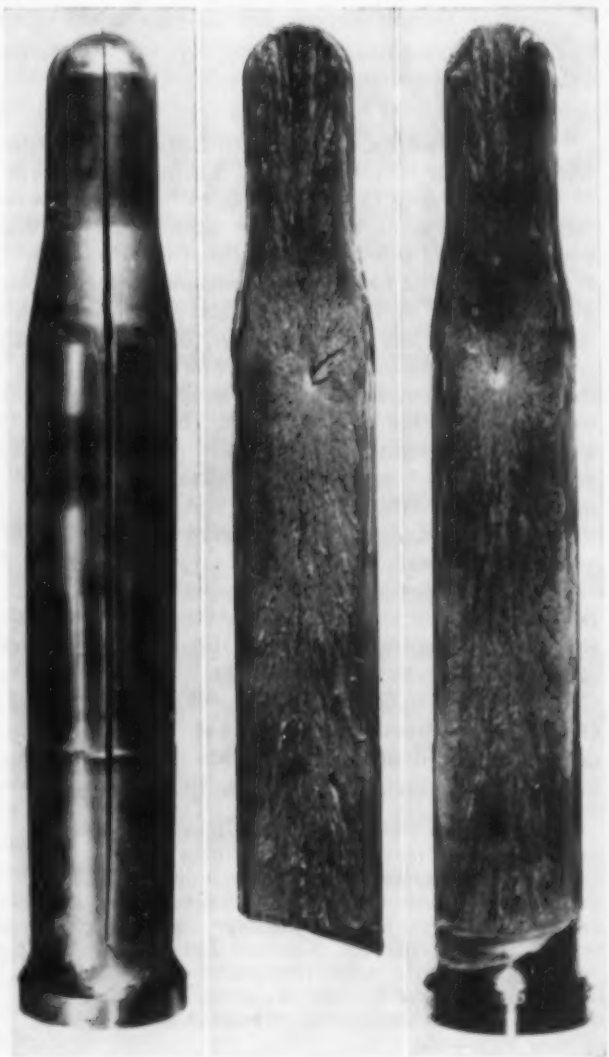


Processing Schedule of Cold Forming Operations Used in Shell Extrusion

along the longitudinal axis. When the two pieces were fitted together, there was a gap ¼ in. wide (first photograph, alongside), indicating the magnitude of the locked-in stresses relieved by the fracture.

Failure originated at a "flake", thought to be caused by either hydrogen occlusion or hardening stresses, and developed into a typical fatigue fracture. The flake can be seen in the upper section of the fractured surface at right. The growing stresses in the plane normal to the plane of fracture caused the diameter of the punch to increase during drawing and to pinch the shell being formed. The gradual increase in the amount of strain caused the increase in frequency of the draw failures.

The punch was made of high-carbon, high-chromium deep hardening tool-steel. The specified heat treatment was an oil quench from 1850° F. and a draw at 300 to 400° F. to a hardness of C - 60 to 61. More than 100,000 shells were drawn with it before it failed.



Left – Punch Fitted Together After Failure Along Longitudinal Axis, Showing ¼-In. Gap. Right – Fracture surface of punch which shows flake from which failure originated

The Supply of Metallurgists With Graduate Training

*By MICHAEL B. BEVER**

The number of Masters' degrees in metallurgy granted in the U.S. hit a peak in 1950 and 1951, dipped sharply in 1952 and 1953, but is on the way back up. In the same period the number of Doctors' degrees has shown a steady upward trend. (A3)

THE SUPPLY of metallurgists with advanced training and the trends affecting this supply are of vital importance to the profession of metallurgy as well as to the metal-producing and metal-consuming industries. In this study, statistics were collected by sending questionnaires to all departments in the United States offering graduate instruction in metallurgy. The data were analyzed and used as a basis for forecasting the number of persons who will complete graduate training in the next few years. The study also produced statistical information on such other aspects as the relation of undergraduate to graduate metallurgical education and the distribution of graduate students between process and physical metallurgy.

An interpretation of trends in metallurgical education requires some reference to the general situation in education. According to a study conducted under the auspices of the American Council on Education and sponsored by the Office of Naval Research, the number of Doctors' degrees conferred in the sciences has doubled in every decade from 1880 to 1950. This trend shows no sign of weakening. Obviously, metallurgy must grow proportionately if it is to hold its position relative to other professions.

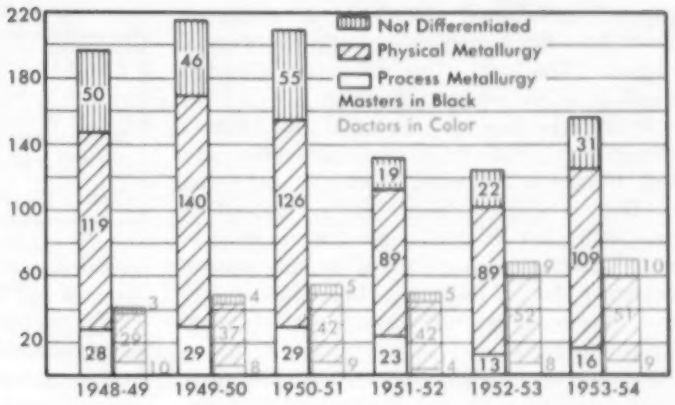
Enrollments and degrees conferred fluctuate widely from year to year, chiefly because of changes in the birth rate, economic conditions and draft policies. Summaries published annually by the Federal Office of Education show that Bachelors' degrees granted in all fields reached their peak in the academic year 1949-50. The peak in Masters' degrees did not occur until the next year and the subsequent decrease was minor. The Doctors' degrees increased steadily throughout the period 1948 to 1954. Degrees in engineering follow similar patterns, but the decrease in engineering Bachelors' degrees from the peak in 1949-50 to 1953-54 was 57.3% compared to 32.5% for all fields.

Method of Survey—The factual information for this study was collected from 48 schools which grant graduate degrees in metallurgy. Forty-six replied to a questionnaire circulated in August 1954, and some information for the other two was obtained from publications of the Federal Office of Education. Some departments of mechanical and chemical engineering or applied science provide opportunities for graduate training in metallurgy without designation in the degrees conferred. These situations are difficult to define statistically, and are not included in this survey.

This study was based on degrees rather than enrollments, because the proportion of part-time

*The study on which this article is based was undertaken by an informal group consisting of Professors Alfred Bornemann (Stevens Institute of Technology), Morris Cohen (Massachusetts Institute of Technology), J. P. Nielsen (New York University), W. O. Philbrook (Carnegie Institute of Technology), with the author (department of metallurgy, Massachusetts Institute of Technology) as chairman. The author alone is responsible for the opinions expressed.

Graph Showing Number of Graduate Degrees in Metallurgy Granted in the U.S. During the Six-Year Period 1948 to 1954. Black bars are for Masters' degrees; bars in color are for Doctors'



students is not the same in all institutions, and degrees are the only definite criterion for the completion of graduate training. Also, industries wishing to employ metallurgists are more concerned with the number of degrees granted than with enrollment figures.

Graduate Degrees in Metallurgy

Masters' and Doctors' degrees for the last six academic years are shown in the accompanying graph in three categories – process metallurgy, physical metallurgy and "not differentiated". The questionnaire suggested that the distinction between process and physical metallurgy be determined by the subject of the thesis or, where this was unworkable, by the emphasis in courses taken. The classification "not differentiated" was included because the distinction between process and physical metallurgy, especially for Masters' degrees, is sometimes impossible or inconvenient. Degrees in this category represent only about 20% of the totals.

The questionnaire defined process metallurgy as "the science and engineering of producing metals from raw materials" and physical metallurgy as "the science underlying the relation between the treatment, structure and properties of metals and the engineering applications of this science, especially to fabrication and heat treatment". It was expressly stated that "physical metallurgy by this definition includes the 'physics of metals' (if the thesis is done in a department of metallurgy) and 'mechanical metallurgy' (plasticity of metals, foundry metallurgy, joining, powder metallurgy)".

The annual totals of Masters' degrees fluctuated considerably over the six-year period. The Doctors' degrees show a much steadier pattern, which accords with the statistics for Doctors' degrees awarded in all fields. The ratio of Doc-

Table I – Field of First Degree (B.S.) of Persons Receiving Graduate Degrees in 1948-1954

Field	Masters'		Ph.D.'s					
			No Prior M.S.		With Prior M.S.		Total	
	Persons	Percent	Persons	Percent	Persons	Percent	Persons	Percent
Metallurgy	602	69.6	60	66.7	149	68.4	209	67.9
Chemical engineering	62	7.2	12	13.3	18	8.3	30	9.7
Mechanical engineering	56	6.5	9	10.0	14	6.4	23	7.5
Chemistry	46	5.3	3	3.3	20	9.2	23	7.5
Physics	40	4.6	3	3.3	12	5.5	15	4.9
General engineering	17	2.0	1	1.1	3	1.4	4	1.2
General science	12	1.4	0	0	0	0	0	0
Mining engineering	11	1.2	0	0	1	0.5	1	0.3
Other	19	2.2	2	2.2	1	0.5	3	1.0
Total known	865*	100.0	90	100.0	218	100.0	308*	100.0

*The field of first degree was not known for 168 masters' degrees and 29 doctors', giving six-year totals of 1033 and 337 respectively.

tors' degrees in process metallurgy to those in physical metallurgy (15.9:84.1) is somewhat lower than the corresponding ratio for Masters' degrees (17.0:83.0). This difference, although small, is in the expected direction.

It must be kept in mind that the Master's degree may either be a terminal degree or a step toward a doctorate. From the proportion of Doctors' degrees in metallurgy granted to men with prior Masters' degrees it can be estimated that approximately 25% of the persons obtaining Masters' degrees continue their studies and, therefore, are not immediately available for employment.

Information was also obtained from the questionnaire on the degree of "Professional Engineer in Metallurgy", defined as a degree "granted by an academic institution to a person having a first (or Bachelor's) degree after additional (graduate) studies". It was stated expressly that this degree has no reference to any state registration or licensing. The answers showed that only 28 such degrees were granted in the entire country over the six-year period. The Engineer's degree, therefore, does not at present have any real importance in metallurgical education.

The Pattern of Graduate Studies

Undergraduate specialization is summarized in Table I. These data are based on more than 80% of all Masters' and more than 90% of all Doctors' degrees given in the six-year period under review. It may be seen that almost 70% of both the Masters' and Doctors' degrees in metallurgy were granted to men who did their undergraduate work in this field. Chemical engineering, mechanical engineering, chemistry and physics account for most of the others. The contribution of metallurgy as an undergraduate specialty is probably understated because in some schools an undergraduate option in metallurgy is offered but leads to a degree in mechanical or chemical engineering.

Table I demonstrates that graduate activities in metallurgy depend critically on the availability and interest of men with undergraduate training in metallurgy. At the same time, the opportunities for attracting graduates of other departments into advanced studies of metallurgy may not have been exhausted; for example, one correspondent reported that the requirements of his department are now being liberalized so that graduates of other departments may take an advanced degree in metallurgy.

Rate of Graduate Study—The questionnaire revealed considerable variation in the proportions of full-time and part-time students. Generally, the proportion of full-time students is larger in small and medium-sized departments; location also is a factor. Some part-time students are in regular industrial employment, while others work exclusively within the academic institution, but only part of their activities carries credit toward a degree, and the rest is devoted to teaching or nonthesis research.

The time required for obtaining graduate degrees shows a considerable range. For the Master's degree it varies from two semesters to two years for full-time students; for part-time students it may be as much as five years. For the Doctor's degree rarely less than three years is required by full-time candidates, and part-time students require correspondingly more time. Some departments do not permit doctorate study by men employed part-time in industry.

Table II – Number of Persons Granted Doctorates Who Had Prior Masters'

	Same School	Different School	All Schools
Process metallurgy	13	19	32
Physical metallurgy	119	51	170
Not differentiated	39	18	57
Total	171	88	259

Table II summarizes data on the prior Masters' degrees for 259 Doctors' degrees. These data show that 77% of the Doctors have prior Masters'. Approximately two-thirds of these Masters' degrees were obtained at the same institutions. It is significant that the change in institutions between the Masters' degrees and Doctors' degrees is larger percentagewise for students of process metallurgy than it is for students of physical metallurgy.

Other Statistical Aspects

Published Statistics—Table III compares statistics on degrees in metallurgy taken from two summaries published annually by the Federal Office of Education and from the questionnaire. The Masters' and Doctors' degrees from these publications do not agree with those found in the present survey nor with each other.

Source (*b*) "Earned Degrees Conferred by Higher Educational Institutions" covers only a fraction of all departments of metallurgy under the heading of "Metallurgy". Moreover, the coverage has deteriorated, and the latest of these bulletins lists Masters' degrees for only

Table III – Comparison of Statistics on Degrees Granted In Metallurgy

Degrees	48-49			49-50			50-51			51-52			52-53			53-54		
	(a)	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*
Bachelors'	738	357	—	961	476	—	802	402	—	581	260	—	550	204	—	495	33	—
Masters'	197	123	197	184	120	215	238	129	210	136	107	131	126	126	124	139	31	156
Doctors'	34	51	42	46	46	49	40	47	56	53	55	51	56	57	69	53	18	70

Sources: *(a)* "Engineering Enrollments and Degrees, 1949" (and subsequent years), Office of Education, Federal Security Agency (1952 and after: U.S. Department of Health, Education and Welfare), Washington, D.C.
(b) "Earned Degrees Conferred by Higher Educational Institutions 1948-49" (and subsequent years), Office of Education, Federal Security Agency (1952 and after: U.S. Department of Health, Education and Welfare).
(c) Questionnaire.

eight departments of metallurgy and Doctors' degrees for only five.

The reduction in the reported totals is partly offset by the effects of a rather broad use of the term "metallurgy" by some institutions. Specifically, degrees in mineral engineering and ceramics are frequently included. If the more restricted definition of the present survey, which is only concerned with process and physical metallurgy, were followed in the published statistics, the totals for metallurgy would be even smaller. The disagreements in the figures for undergraduate studies further illustrate the unsatisfactory state of the published statistical information on metallurgical degrees.

The bulletins on "Earned Degrees . . ." (Source *b*) cover all academic fields and institutions, while those on "Engineering Enrollments and Degrees" (Source *a*) are limited to engineering departments. The latter are more likely to be accurate for a field such as metallurgy, and it is not surprising that they report the larger figures. Most of the "missing" degrees in metallurgy are probably lost under "other engineering degrees". The situation is detrimental to the standing of metallurgy, and corrective measures should be taken. Improvement can come about only if the department heads insist with the administrative officials of their own institutions that the degrees in metallurgy be clearly segregated in their reports to the Federal Office of Education.

Relative Size of Departments—A recent study by Bornemann (*Metal Progress*, March 1954, p. 97) dealing with the educational facilities in metallurgy included some information on the relative size of departments. The present survey was not concerned with organizational details, but one aspect of graduate training bearing on the supply of metallurgists is indicated by a listing of institutions in groups arranged by the number of graduate degrees conferred.

Of 47 institutions granting Masters' degrees, seven granted 1 to 5 degrees over a six-year period, eight granted 6 to 10 over the same period, seven granted 11 to 15, and five each granted 16 to 20, 21 to 25, and 26 to 30. Two granted 31 to 35, three 36 to 40, and one each gave 43, 55, 59, 75 and 104 Masters' degrees during these six years. Of the 32 institutions with active Doctors' programs, two-thirds conferred no more than two degrees per year on the average (22 institutions, each granting 1 to 10 doctorates over the six-year period).

General Comments and Forecast

A striking feature of this survey is that Doctors' degrees in metallurgy account for more than 10% of all doctorates in engineering. For Masters' degrees the fraction is only about 4%.

Graduate instruction given by other departments may also contribute to the supply of manpower for advanced work in metallurgy. Mechanical engineers, physical chemists and applied physicists, in particular, have supplied manpower for metallurgical research. In times of shortage, however, many other demands are made on this reservoir.

Metallurgists trained abroad are a sporadic source of supply, probably not important numerically. On the other hand, among the graduate students trained in the United States are foreigners who return to their own countries. In some institutions foreign students account for 10 to 20% of the graduate degrees in metallurgy. In many others the percentage is undoubtedly much smaller. A deduction of 10% from the totals would seem to be an appropriate correction for foreign students not available for employment in this country. The training of foreign students does not interfere with the domstic supply, however, since in most institutions the capacity for graduate education in metallurgy exceeds the en-

(*Continued on page* 168)

Controlling Corrosion With Cathodic Protection

*By H. R. LUDEKER**

Corrosion, which costs our country billions of dollars each year, can be controlled by interposing an electrical resistance in the corrosion circuit or by limiting the difference in potentials of the anodic and cathodic areas. (R10)

MANY METHODS, including coatings, inhibitors and proper selection of construction materials, have been used to combat and control the corrosion rate. Among the more recent of these is cathodic protection, which is the application of a protective current from an auxiliary anode to oppose the corrosion current from the surface of the protected structure.

Corrosion of metal in contact with soil or water is electrochemical in nature. In this corrosion system the metal entering the electrolyte at the anodic area results in the flow of current to the cathodic areas. The corrosion may be controlled by interposing an electrical resistance in the corrosion circuit or by limiting the potential difference between the anodic and cathodic areas. Most methods of controlling corrosion merely tend to lower its rate or magnitude. An applied protective current opposes the flow of corrosion current and when applied in adequate amounts will essentially prevent any metal loss. This may not always be economically practical, but it is justifiable in many instances. Of all methods of corrosion control, cathodic protection has the distinct practical advantage that it can be applied to submerged or buried steel without exposure of the entire structure for treatment.

The causes of corrosion may be divided into two categories: (*a*) galvanic currents and (*b*) stray direct currents.

Corrosion of subsurface structures occurs by *galvanic* currents originating between discrete areas of oxidation and reduction reactions. Typical examples are a dissimilar metal couple, nonuniformities existing on the metal surface, or nonuniformities in the environment in contact with the metal surface. Intergranular attack is a form of galvanic corrosion, since the atomic arrangement is looser at the grain boundaries and the potential at the grain boundaries is consistently different from that of the grain interiors.

Corrosion of subsurface structures occurs by *stray* currents that flow in circuits grounded at more than one point. These are found near a leakage of direct current, such as railway systems, in plants using ground or faulty return systems and in mining areas. In recent years another source of stray direct currents has resulted from the application of cathodic protection to underground structures. By design of the protective current source to minimize the harmful potential gradient and by proper bonding, all harmful effects may be eliminated. The neigh-

*Electro Rust-Proofing Corp., Belleville, N. J.

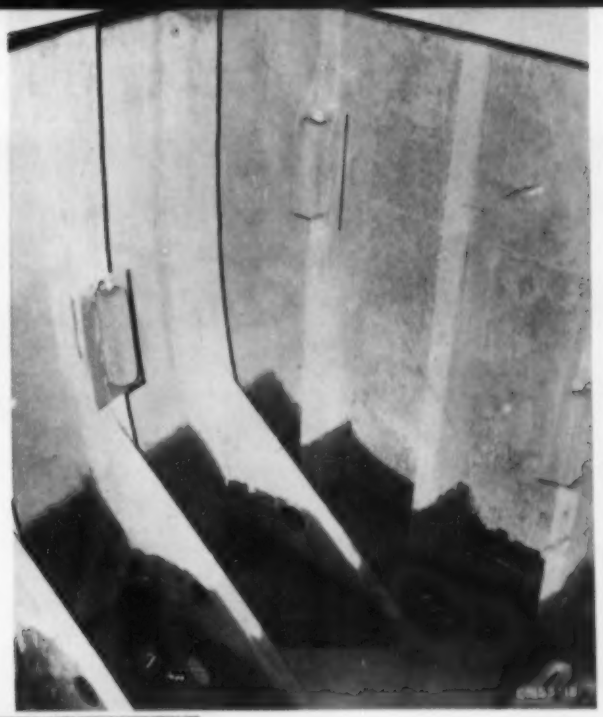
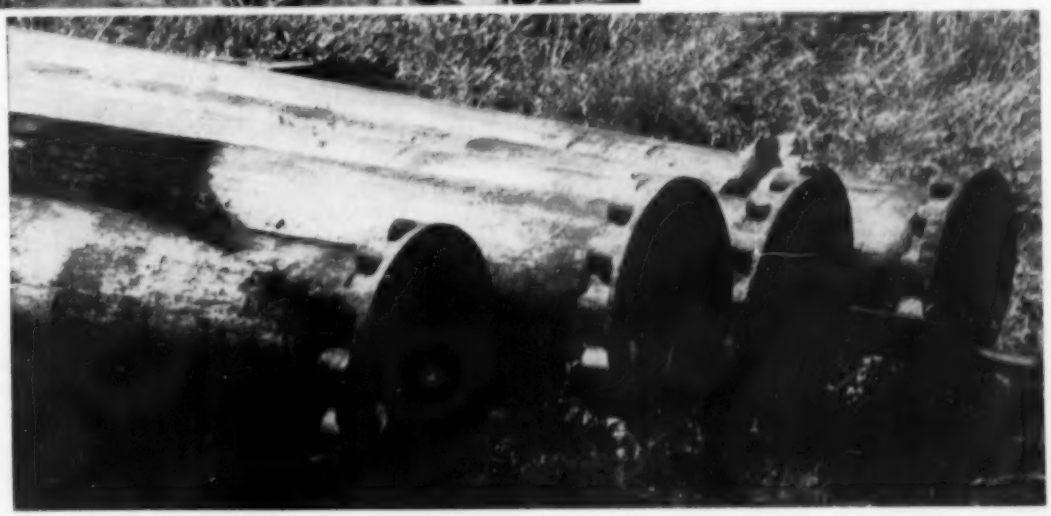


Fig. 1 – Cathodic Protection With Magnesium Anodes Bolted to Ship's Frame Prevents the Corrosion of Ballast Tanks

Fig. 2 – Column Pipe for Well Without Cathodic Protection Required Replacement After 18 Months

Fig. 3 – Cathodically Protected Column Pipe Showed no Attack by Corrosion After Nearly 3 Years' Service



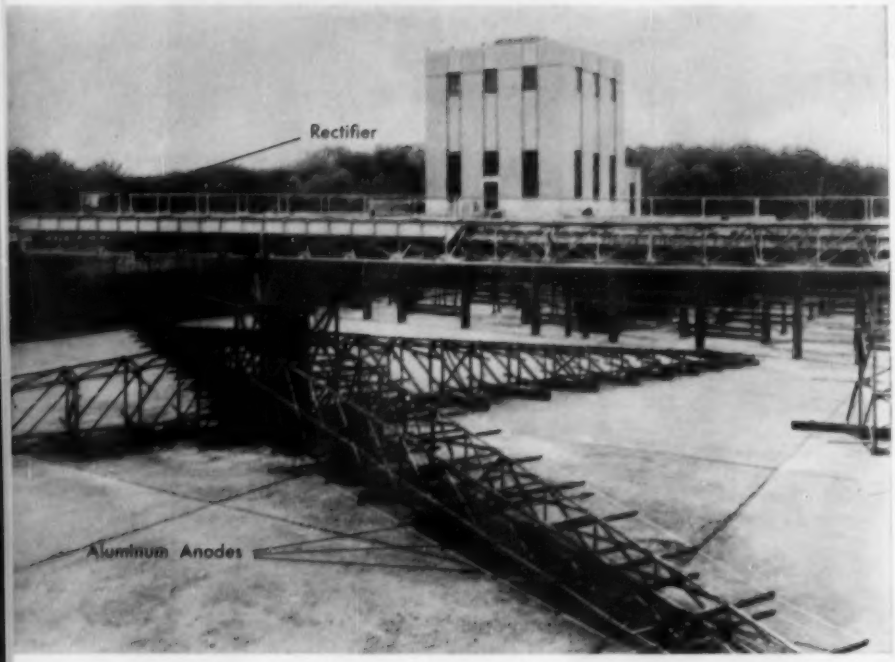


Fig. 4 – Aluminum Anodes Protect Rake Arms of Waste Treatment Structure. Current for the system comes from rectifier on the platform

boring or affected structures are benefited by well-coordinated interference control.

The protective current may be forced to flow by a metal whose inherent potential in the specific environment is more anodic than that of the metal to be protected, or the current may be forced to flow from auxiliary anodes by an external potential source.

The most frequently used anodic metals are high-purity zinc (less than 0.0014% Fe) and magnesium alloy (6% Al and 3% Zn). Recently a magnesium alloy containing manganese has been formulated having a potential that is 0.25 v. more anodic than the alloys commonly used.

Rectifiers and motor generators are the external sources of potential. The auxiliary anodes will be sacrificial when the anode reaction is the solution of the metallic ions (for example, iron or aluminum) or they will be nonsacrificial (graphite, platinum or duriron) when the anode reaction is the liberation of oxygen or chlorine.

Among the many engineering problems that arise in the design of a cathodic protection system, two basic questions evolve: "How much current will be required and how can we measure the achievement of adequate protection?" Protective current requirements are determined by a large number of variables including the spatial relation of anodic and cathodic areas on corroding structure, temperature, oxygen concentration, velocity, chemical constituents and structure. A resistive film on the metal surface (paint coating, rust film or calcareous deposit) tends to lower the protective current requirements. Although the influence of the variables singly can be demonstrated, the actual protective current requirements cannot be accurately predicted for a specific corrosion problem. It has been said that the protective current requirements change from place to place and time to time, so the actual requirements must be established by observing the response of the structure to applied current. Insufficient current will give only partial protection and an excess of current will be expensive and may cause blistering and eventual failure of a coating.

Following the procedure of diagnosis and treatment, the condition of the structure must be evaluated. By definition corrosion ceases when: (*a*) The cathode is polarized to the open circuit potential of the anode; (*b*) The pH at the metal surface exceeds 9.5; (*c*) The net current flow out of the anodic area is zero. These principles have been adapted to fit the needs of the corrosion engineer. One of the most useful methods of evaluating the effectiveness of a cathodic protection system is a visual or physical inspection of the protected structure.

Some of the electrical methods used to establish the degree of protection achieved are:

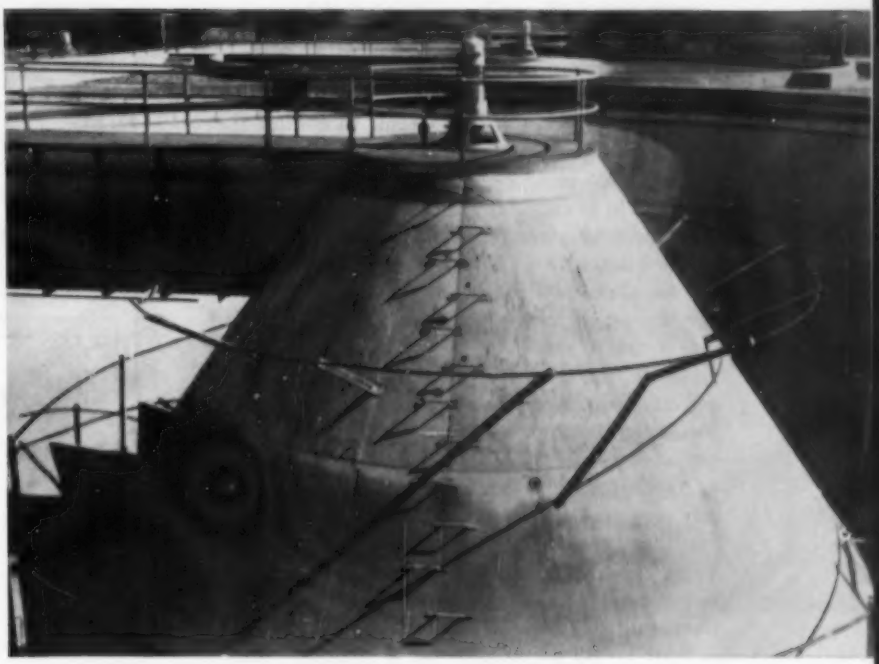


Fig. 5 — Circular Aluminum Anodes Protect the Exterior of This Spaulding Precipitator. Other anodes are installed inside the cone in the mixing zone as well as on the inside and outside of the flume

1. Lowering the potential of the structure to −0.85 v. when referred to a Cu-$CuSO_4$ half-cell.

2. Lowering the potential of the structure to its environment by some arbitrary amount, such as 0.2 to 0.3 v.

3. Using two reference electrodes to measure a zero potential gradient normal to the protected structure.

4. Break in the log potential versus applied current curve established by use of the Pearson "Null" method.

Applications

In recent years corrosion engineers have adapted cathodic protection to many corrosion problems. An early use of the cathodic protection principle was made by Sir Humphrey Davy when he attached zinc plates to ships in contact with sea water to prevent corrosion of the copper sheathing. Recent developments in galvanic anodes and their installation have provided effective corrosion control in the salt water ballast tanks of cargo ships and prevented severe pitting (up to 0.2 in. per year) on bottoms of tankers carrying sour crude from the Middle East. Magnesium anodes may be bolted to the ship's frame and backed with rubber shields, Fig. 1, or attached to the ship's members with brackets molded into the anode. Coordination of operating conditions with cathodic protection is required to obtain sufficient protective effect during ballast time to retard corrosion during nonballast periods.

For many years maintenance on a steel water storage tank had consisted of periodic painting (every 3 to 5 years) of the interior steel and occasional (20 to 25 years) extensive repairs or replacement. Today, through the use of cathodic protection, repainting may only be needed to lower the operating costs of the cathodic protection system in environments difficult to protect against. The useful life of the tank without serious repairs may be extended four to five times its previous expectancy. A typical cathodic protection system for a water tank would consist of a rectifier and the required number of anodes of steel, aluminum, platinum, graphite or duriron. Current requirements are governed by the water and surface conditions.

Maintenance and repairs in deep wells are costly operations, since severe corrosion of the well casing and screen usually requires drilling a new well and corrosion on other parts requires premature pulling of the well to replace parts. After almost three years of operation with cathodic protection a column pipe showed no evidence of attack, Fig. 3. A column pipe without cathodic protection in this same deep well required replacement after 18 months' service, Fig. 2. Protection of the column pipe, casing,

screen and shaft can be accomplished by proper positioning of anodes in the annular spaces between shaft, column pipe and casing. It is often necessary when galvanic anodes are used to install fixed resistors in the circuit to control the anode protective current output.

Cathodic protection has been particularly applicable to complex structures for water, sewage and waste treatment such as clarifiers (Fig. 4) and flocculators. Figure 4 shows the location of the aluminum anodes on rake arms and the rectifier on the center platform. Eight years after the structure was built, pitting was severe at the flaws in the coating. Cathodic protection was effectively applied at a cost of $17,000 against an estimated $45,000 for conditioning the surface and recoating.

Another type of underwater equipment that has presented a serious corrosion problem is the traveling screen. These screens last four to seven years in sea water service. Cathodic protection is being applied and effective corrosion control is obtained.

Prior to the use of cathodic protection, corrosion on pilings submerged in sea water was a problem about which little could be done. In contrast to all the previously mentioned examples, this structure could not be repainted once it had been installed and it was known that most of the paint would eventually be damaged, especially on the portions below the mud-line during the driving of the piles. Therefore, even though most engineers designed this part with a high safety factor, there still were many conditions under which the structure would not last over 20 years. For example, in the northeast harbor area a sheet steel piling over ½ in. thick was completely penetrated in 25 years. Cathodic protection is now being applied to many piling structures, including the three new piers for the Port of New York Authority (Fig. 6) at Port Newark and Hoboken, N.J.

The best known application of cathodic protection is the buried transmission and distribution pipeline systems. Corrosion on this type of structure is not always evident until the metal loss has resulted in pipe penetration. Survey methods have been developed to diagnose the corrosion conditions and to predict future difficulties.

Protection of bare pipelines usually requires a high current density (1 to 5 milliamp. per sq.ft.) or 8 to 40 amp. for 1 mile of 6-in. line. A more economical method is to apply a good coating when the line is installed and to protect against flaws with cathodic protection.

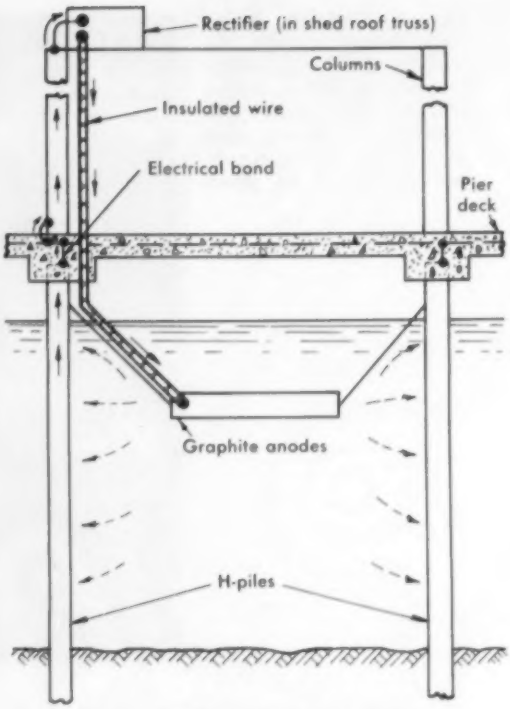


Fig. 6 – Corrosion of Piles of New Pier at Hoboken, N. J., Is Prevented Cathodically. System uses 200 graphite anodes, each supplied with 10 to 15 v. direct current. Cost of protection will be about $3 per pile per year for current and maintenance

Only a few milliamperes per mile may be required to assure corrosion control at the flaws of better coating systems. In a system designed for a life of 25 years, the total cost of preliminary testing, engineering, all materials and labor for the cathodic protection of 375 miles of 16, 14 and 10-in. pipe, including 250 permanent test stations, will be less than 2¢ per sq.ft. Power cost for the rectifiers at the present time is less than 0.01¢ per sq.ft. per year.

Many other applications of cathodic protection have been found in recent years including open-box condensers, underground cables, hot water tanks, condenser water boxes, buried storage tanks, sand filters, sewage outfall lines, ships in storage, Spaulding precipitators (Fig. 5) and power plant substructures.

Corrosion of iron has been a problem to man since he began using it. For years it was just another problem to live with, but now, many industries have found in cathodic protection the answer to the perennial question, "What can we do about corrosion?"

Hardenability of Carbo-Nitrided Carbon Steel

*By R. H. MARSHALL**

Increase in grain size or manganese content increases hardenability of carbo-nitrided carbon steels. The effect of grain size is greater than the effect of manganese in the range investigated. (J26, ST)

OIL QUENCHING of cabon steel parts is made possible by the use of the carbo-nitriding process, yet there is relatively little information available about the section sizes which can be hardened by oil. Manganese and grain size are the two greatest variables in carbon steels, and their effects on the hardenability of carburized cases are known. The added influence of nitrogen, however, has not been determined extensively, although at a low manganese level it has been found to increase hardenability up to 300%.† This article summarizes some work done recently to evaluate further the influence of manganese and grain size on hardenability of carbo-nitrided carbon steels.

Hot rolled carbon steels with manganese contents ranging from 0.42 to 1.60% were used. The analyses are listed in Table I. Jominy test bars were carbo-nitrided in regular batch production heat treating cycles. Each test bar was hung upon a charge and then removed to the standard quenching fixture when the production charge was ready for quenching. A typical production cycle was as follows:

Temperature	1625° F.
RX gas, cu. ft. per hr.	410
Methane, cu. ft. per hr.	16
Ammonia, cu. ft. per hr.	50
Time at heat	3.25 hr.
Dew point	10 to 15° F.
Case depth (Brinell glass)	0.028 to 0.32 in.
Diffusion cycle	
No methane	last 0.5 hr.
No ammonia	last 0.75 hr.

*Chief Materials Engineer, Frank G. Hough Co., Libertyville, Ill.

†Powell, Bever and Floe, in "The Carbo-Nitriding of Boron Steels", *Transactions*, Vol. 46, 1954, p. 1359, showed the influence of nitrogen on the Jominy hardenability of a 0.43% manganese steel which apparently was coarse grained. Depth of hardening to Rockwell C-50 was moved from three sixteenths in straight carburizing to 12 sixteenths in carbo-nitriding at 1600° F.

Table I – Chemical Composition of Steels Tested

Steel	Composition, %						Bar Diameter
	C	Mn	Si	Cr	Ni	Mo	
1020	0.16	0.42	0.06	0.04	0.07	0.02	1.250 in.
1020	0.19	0.47	0.20	0.06	0.12	0.02	1.250
1022	0.25	0.87	0.27	0.06	0.06	0.02	1.281
1022	0.22	0.80	0.21	0.06	0.08	0.03	1.234
1117	0.20	1.06	0.08	0.05	0.07	0.02	1.218
1145	0.47	1.00	0.22	0.12	0.07	0.03	1.250
1117	0.15	1.35	0.03	—	—	—	1.250
1141	0.42	1.44	0.22	—	—	—	1.750
1141	0.44	1.60	0.22	—	—	—	1.250

Representative carbon and hardness gradients averaged for numerous production parts are shown in Table II. The heat treating furnace was a Surface Combustion batch-type "Allcase" furnace with a hooded atmosphere quench. All testing apparatus and procedure followed the standards set up by the Society of Automotive Engineers.

Test Procedures

Hardenability curves were determined from an average of the hardness values obtained on two flats. One pair of flats was ground 0.005 in. deep and the other pair 0.010 in. The Rockwell A scale was used on all flats. The curves shown in Fig. 1 give individual comparisons of grain size for four manganese levels. These curves were obtained at 0.005 in. below the surface for manganese up to 1.06% and at 0.010 in. for manganese contents greater than 1.06%. Both are at levels of maximum hardenability.

Each bar was sectioned transversely at the unhardened end and examined for "as-quenched" grain size and case depth. The results are summarized in Table III and compared with the actual McQuaid-Ehn grain size and the numerical values obtained from Fig. 1 for the distance to C-50.

Table III – Relationship Between Grain Size and Hardenability for Various Manganese Contents

Mn	McQuaid-Ehn Grain Size (1700° F.)	As-Quenched Grain Size	Case Depth, Brinell Glass	Distance to Rockwell C-50, Sixteenths
0.42%	3 to 5	4 to 5	0.028 in.	10
0.47	7 to 8	7 to 8	0.022	4.5
0.87	8 Dup. 6	7 to 8	0.024	8
0.80	3 to 5	4 to 5	0.030	18
1.06	3 to 5	6 to 7	0.020	12
1.00	7 to 8	7 to 8	0.022	8
1.35	3 to 5	4 to 5	0.028	21
1.44	7 to 8	6 to 7	0.022	9
1.60	7 to 8	7 to 8	0.022	10

Discussion of Results

The Jominy curves give the hardenability for the conditions within the case of the steels tested which result in maximum hardenability. Boegehold gave the relation between Jominy depth, bar diameter, and various positions within the bar for quenching in still oil. By using his curves with these hardenability curves, it is possible to predict the bar sizes hardenable for any composition. From our results we calculated the following theoretical bar sizes hardenable to C-60 on the surface:

Table II – Typical Carbon and Hardness Gradients

Depth	Carbon	Rockwell Hardness
0.000-0.005 in.	1.02%	C-62 at surface
0.005-0.010	0.94	C-64 at 0.002 in.
0.010-0.015	0.91	C-63 at 0.009
0.015-0.020	0.76	C-56 at 0.018
0.020-0.025	0.50	C-43 at 0.020
0.025-0.030	0.41	C-29 at 0.023

	Diameter of Bar	
Manganese	Fine Grain	Coarse Grain
0.42 and 0.47%	1.25 in.	2.25 in.
0.80 and 0.87	2.0	3.75
1.35 and 1.60	2.5	3.75

These sizes are purely theoretical and are for the hardenabilities obtained only.

The hardenability curve of the 1.06% manganese steel with coarse grain is out of position with respect to the other steels studied. It indicates a hardenability inferior to the 0.80% manganese coarse-grained steel. The reason for this discrepancy is that the grain was much finer than the McQuaid-Ehn grain size indicated it would be. The curve is, therefore, in an intermediate position between coarse and fine grain.

The effect of manganese content and grain size on the hardenability is summarized in Fig. 2. The dis-

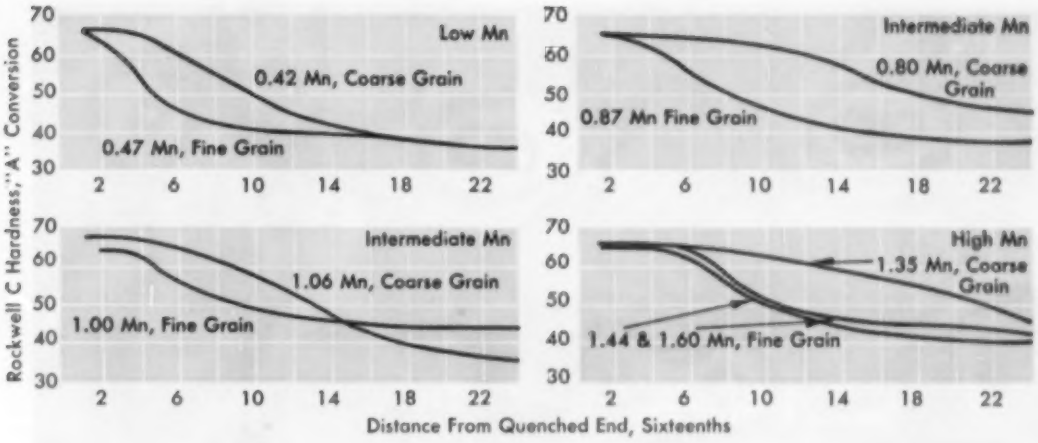


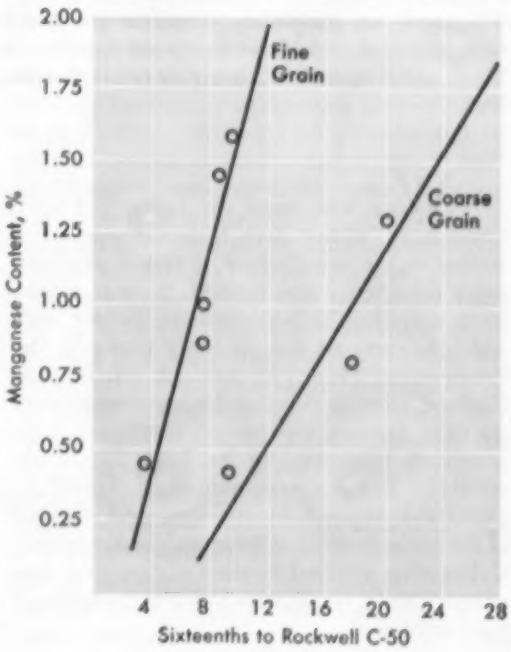
Fig. 1 – End-Quench Hardenability of Steels of Varying Manganese Levels Carbo-Nitrided at 1625° F. for 3.25 Hr. Hardness values were obtained at 0.005 in. below the surface, except for the high-manganese steels at 0.010 in. below

tance to a hardness value of C-50 is used for comparison. Both higher manganese and coarser grain increase the hardenability of the carbo-nitrided steel. The data appear to be typical of grain size variation between 4 to 5 and 7 to 8. These are "as quenched" grain sizes and cannot be anticipated from the McQuaid-Ehn grain size ratings. It has been the experience of the author that failure of a steel to harden properly can often be traced to the fact that the steel in question had not coarsened in grain as predicted. The behavior of the 1.06% Mn steel is typical. The McQuaid-Ehn test indicated that this particular steel should be coarse-grained. It did not coarsen, however, and subnormal hardenability was the result. It is not included in Fig. 2 for this reason.

The case depth reactions appear also to be quite dependent on grain size. The depth of case in the fine-grained steels is only 0.022 in. while in the coarse-grained steels it is 0.028 in. This difference is generally shown in carburizing and in carbo-nitriding. Perhaps an extra 0.006-in. case depth should be specified to compensate for erratic grain coarsening.

Points questioned in many carbo-nitriding experiments have been the influence of gas composition, volume, velocity and the effect of steel reaction on the gas. Because the test bars were treated with a full production charge of metal, they represent all the metal in the charge and are typical of the process. A furnace fan provides thorough mixing and agitation of the furnace gases, and forces the gases through the work. The test bar was, therefore, subject to the same gas composition as every portion of the charge. Gas volume and velocity were known to be adequate, and inlet gas composition was considered acceptable for production work. The data indicate, that, with proper grain size and manganese content, sections 3.75 in. in diameter are hardenable to Rockwell C-60 in oil.

Fig. 2 – Effect of Manganese Content and Grain Size on Hardenability as Measured by Distance Along the Jominy Bar to a Hardness of C-50



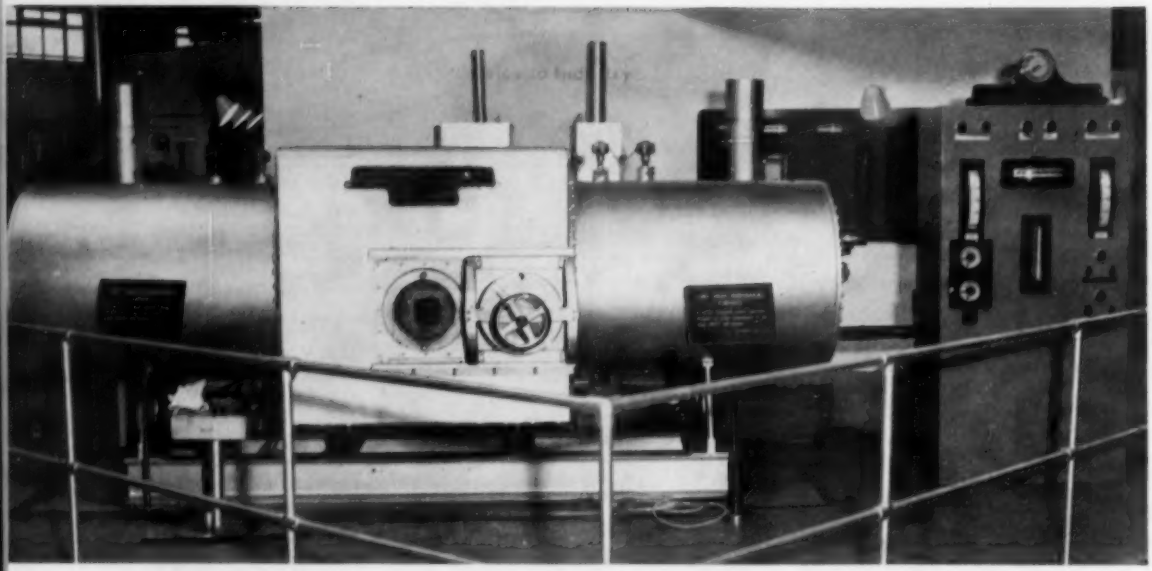


Fig. 1 – Front View of Furnace

4000° F. Gas Furnace

*By HORACE B. DREVER**

A completely automatic gas-fired furnace developed in England is capable of continued operation in the range of 3200 to 4000° F., using air rather than oxygen for combustion. (Jgeneral)

With the trend in industry toward increasingly higher and higher temperatures needed in the development of new superalloys, super refractories and cermets, there is a need for a simplified high-temperature furnace with which to carry on the necessary research. The Incandescent Heat Co., Ltd. of Birmingham, England, recently developed a high-temperature gas-fired furnace capable of continued, fully automatic operation up to 2200° C. (nearly 4000° F.). It has a maximum limit of 2400° C. (4350° F.) imposed by the structural material of the main chamber – dense stabilized zirconia. Unlike other gas-fired furnaces of its type, it uses ordinary air for combustion rather than expensive pure oxygen.

The furnace is equipped with two regenerators, one attached to each side, the whole making a neat unit. Complete with piping and valving, it occupies a floor space of only 12.5 × 5 ft. (Fig. 1). It is the regenerators that make it possible to operate the furnace without pure oxygen, and so efficient are they that the exhaust gas temperatures are below 500° F.

The furnace interior is 14 in. in each dimension, although this can be varied. It is lined with dense, stabilized zirconia backed up with insulating zirconia and with standard insulating brick outside of that. The shell temperature, when the furnace is at 3600° F. is not over 170° F.

All piping and auxiliary parts are behind the

*Secretary, Drever Co., Bethayres, Pa.

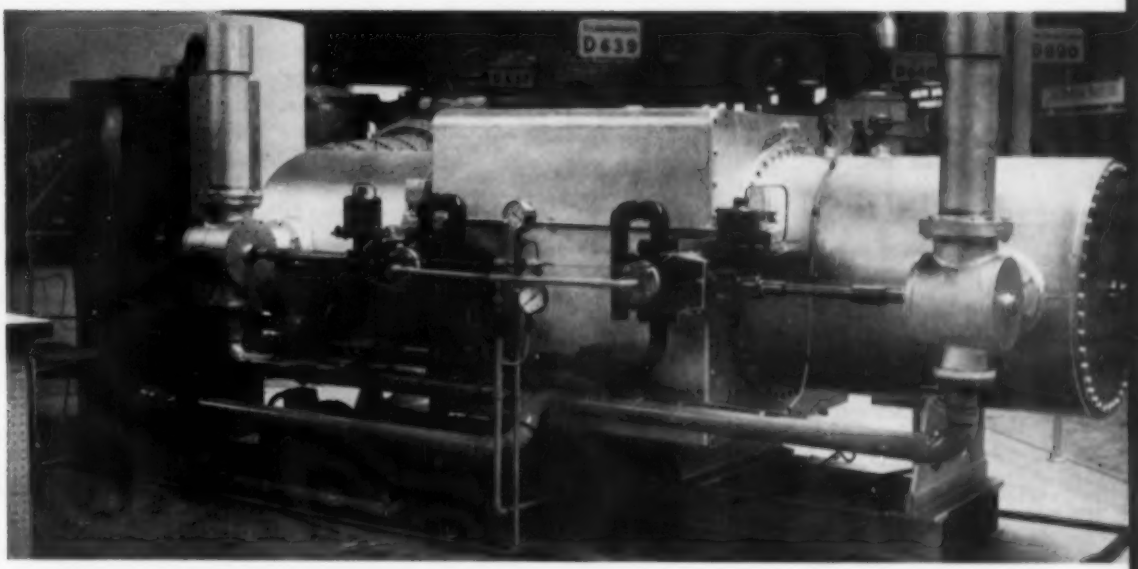


Fig. 2 – Rear View, Showing Auxiliary Equipment, Valves and Piping

furnace, as shown in Fig. 2. It shows the large three-way air control valves to the regenerators along with the controlling linkage. These valves and the gas valves connected in parallel are controlled by pneumatic controllers. These in turn are connected with an automatic timing device that changes the flow of gas every 30 sec. in a manner similar to an openhearth furnace.

The gas is fed through two banks of delivery tubes, three tubes to each bank, located on each side of the furnace in the exit from the regenerators. They are not burners in the conventional meaning of the word. Since the furnace is intended for operation above 1800° C. (3270° F.), it is not necessary to use either mixing or premix burners such as are universally used with lower temperature gas furnaces. At the temperatures of operation, combustion of the raw gas fed by the delivery tubes with the superheated air is practically instantaneous. Gas consumption at 2100° C. (3810° F.) is equivalent to 617,500 Btu. per hr. The delivery tubes have a tip of 37-18 nickel-chromium alloy. They are cooled in use by the raw gas passing through, while those not in use are kept cool by bypassing air from the blower.

The charge is placed within the heating chamber and the entrance closed with a series of loose bricks of proper composition, forming a wicket door. The whole is sealed with cement for gas tightness and is further sealed by the sliding breech door visible in Fig. 1.

Lighting off is very simple. A gas torch, oily rag or other ignition source is placed in the furnace chamber and the fuel and air turned on. Within a few minutes the temperature of the two entry ports exceeds the minimum temperature for re-ignition and reversal of the regenerators begins. There has never been any trouble in lighting this furnace.

Since the furnace was designed in England for low-Btu. town gas with a fast flame, the question has been raised as to whether natural gas, with a low rate of flame propagation, could be used. The furnace has recently been operated up to 2150° C. (3900° F.) on propane and its performance was as good as on city gas. It must also be remembered that the air preheat temperature is approximately 1500° C. (2730° F.), a condition that has a strong influence over combustion intensity and flame velocities.

Another question raised by prospective users has been whether the butterfly reversing valves can take the high temperatures successfully. As stated before, the exhaust temperature is under 500° F. and there is a cycle change every 30 sec. causing cool air to flow through the valve. Because of this alternate flow, the valves never get more than hand hot!

It is hoped that this equipment will become of value to industrial and research laboratories, freeing the engineers from details of operation because of its simplicity and completely automatic operation.

Pattern for Progress

If you were managing an organization the size of Union Carbide and Carbon Corp., responsible not only to its stockholders but also to its 70,000 employees, how would you plan for a steady growth of sales better than the rate of growth of the national economy? The pat and simple answer is some sort of a research program. Research, however, requires much patience plus a fine balance between direction of effort and freedom from supervision. The Metals Research Laboratories of one of the subsidiaries, the Electro Metallurgical Co. in Niagara Falls, N.Y., seems to be a successful example of how research can be used in this manner.

The firm is not a johnny-come-lately in research. Shortly after the Corporation was organized, it purchased Niagara Research Laboratories, a group which under the late, great Frederick Becket, had pioneered the manufacture and use of ferrochromium and silicon metal. Subsequent achievements in the field of stainless steels, heat resisting alloys, and silicon-reduced metals are too well known to need recounting, and are sufficient evidence that research activity is well planned and has consistently produced results, both scientific and commercial.

In my tour through the laboratory I expected to meet an unusually competent group of metallurgists whose work would be balanced between steelmaking and alloy applicatioa. I was certainly not disappointed in the metallurgical personnel but was surprised by the wide range of specialties of the men who work so closely with this nucleus of metallurgists. They include electrical engineers, mechanical engineers, physicists, chemists, chemical engineers, specialists in electronics, magnetics, mineral dressing and virtually any field of science or engineering that could contribute to the most effective use of metals. The method in which these varied talents are employed is probably typified by the development work in the "reactive metal" section. One of its immediate problems is titanium.

The trouble with this metal – the earth's fourth most abundant – starts with the very fact that titanium is so abundant that it is usually found in low-grade ores. The metal now being produced comes from high-grade rutile, whose present known sources will be exhausted rapidly by the projected expansion of tonnage. So the mineral dressing group is working on the beneficiation of low-grade ores such as common ilmenite which has not yet been economical to use.

Subsequent steps in the process are chlorination of the ore, reduction of the chloride to metal sponge by sodium, and removal of the impurities. This falls under the general classification of extractive metallurgy. It also is a costly set of operations. Thus, it is obvious why the men at work here generally have chemistry, physics, or chemical engineering backgrounds. Although titanium sponge is the product that Electromet intends to make, the metallurgical group is investigating melting and alloying practices and

applications of titanium so they will be able to provide their customers the same type of support they have given stainless steel producers. Much of the work is directed toward titanium alloys for civilian applications and toward fabrication economies. It also is intensive, since Electromet is committed to produce 15,000,000 lb. of sponge in 1956.

One of the main problems of the management of this growing laboratory is recruiting the proper type of researcher. For the higher-level position he should be an expert on something, and that "something" ranges over a wide field of knowledge. For example, psychologists might readily be added to a staff if the directors would accept the proposition that sound psychological techniques could increase productivity of labor even by 1%. Think what the savings would be for 70,000 employees throughout the Corporation's activities. Biology seems like a field quite far from metallurgy, but biologists are now using techniques whereby they examine unit cells and are attempting even to subdivide the unit cell; the same techniques might prove useful in fundamental research on metal crystals. A biology department in a metals research laboratory is not too remote a possibility.

Technical personnel must be able to discuss their fields not only in the specialized vocabulary used by their fellow scientists but also to translate it so their associates in the laboratory will also understand. At present, two of the physicists are being watched pretty closely by their nonphysicist colleagues because of their unique ability to answer embarrassing questions in the language of higher mathematics. The interest is more than a little selfish, as the two physicists are the possessors of a radio set with which they listen to electrons whispering to atoms, as explained to this layman. The mere metallurgists are watching these experiments carefully and are confident that the spirit of cooperation evident throughout the laboratory will convert the physicists by next September whereupon the equipment will be available for listening in on the next World Series. J. T.

Applications of Powder Metallurgy

*Reported by POL DUWEZ**

Five papers presented at the Western Metal Congress last March indicate the wide range of applications of powder metallurgy throughout industry. (H general)

THE RELATIVELY young field of powder metallurgy has found a fertile environment in the rapidly expanding industrial Southwest, as indicated by the success of the panel session held during the Western Metal Congress in Los Angeles. The subject of the discussion was powder metallurgy in its broadest sense. In addition to metal powder products it covered nonmetallic materials such as ferrites, cermets, carbides and use of powders in high-temperature brazing.

John Q. Adams, metallurgical consultant, opened the session with a detailed review of the

*Professor of Mechanical Engineering, California Institute of Technology, Pasadena.

field of magnetic materials made by compacting and sintering powders. For permanent magnets, powder-metal parts are still widely used in spite of the competition of cast materials because of superior physical properties, mostly due to finer grain size. Other advantages of powder metallurgy are better impact strength, less danger of developing cracks, no grain-boundary segregation of impurities, and closer dimensional control.

Transformer-grade silicon sheets are being considered as an application of powder metallurgy. Here again, close control of composition and freedom from gas, whose presence is very harmful to the properties of soft magnetic materials, make powder metallurgy attractive. According to the speaker, square-loop magnetic materials can also be fabricated from powders (for example, the 50% Fe, 50% Ni Nicaloy) with notable improvements over corresponding cast and wrought products.

The most important factors, in comparing the cost of powder metallurgy with other techniques, are the size and shape of the finished part and the number of parts to be fabricated. The speaker expressed the opinion that when close control of analysis and freedom from impurities and gases are required, powder metallurgy is the ideal method.

The rapidly expanding field of ferrites was discussed next. Although the electronics industry is now the most important consumer of ferrites, applications in the powder industry would increase if the Curie temperature of ferrites could be raised appreciably. The versatility in the magnetic properties of ferrites is so desirable that attempts are now being made to develop magnetically hard ferrites. A considerable amount of research – particularly in France – is devoted to this problem and some of the experimental materials obtained so far could be competitive with some grades of Alnico.

Application of Carbides—Malcolm F. Judkins, manager, New Products Div., Firth-Sterling, Inc., described in detail the fabrication of tungsten carbide tools and outlined the various problems facing the producer. The importance of particle size distribution, mixing, compacting pressure, sintering temperature and sintering atmosphere was discussed. In spite of the high quality of the cutting tools which are on the market today, development of improved hard metals is continuing. Problems in machining have resulted from the steadily increasing use of new metals and alloys such as titanium and zirconium, and cutting tools must be improved to meet these problems.

Compounds other than carbides are suitable for cutting tools as far as their hardness is concerned. Research on aluminum oxide was initiated during the war when a shortage of tungsten carbide threatened to slow down production. It was practically discontinued after the war, but more recently the potentialities of alumina have been reconsidered and it appears that high-quality products can replace tungsten carbide tools for many applications.

The field of carbide-base materials is not limited to the cutting tools. Small gas turbine wheels made of metal-bonded titanium carbide have shown promise. Although these materials are basically the same as cutting tools they have to stand high stress at high temperature, must resist thermal and mechanical shock and be stable in the presence of oxidizing gases. Fabrication problems are also more complicated than in the cutting tool industry, because of shape and tolerance requirements. The field of carbides and other hard metals for high-temperature use is one of the most fascinating in powder metallurgy today. The large amount of fundamental and applied research devoted to it points to early industrial realizations, especially in high-temperature gas turbines.

Sintered Aluminum Powder—Another aspect of the importance of powder metallurgy in connection with high-temperature materials was presented by Pol Duwez, professor of mechanical engineering at California Institute of Technology. High-strength parts for high-temperature use with compositions identical to wrought steel can be made by powder metallurgy, using elemental or pre-alloyed powders. The great success of powder metallurgy in this field, however, is in the preparation of pseudo-alloys in which one of the constituents is a finely dispersed oxide phase. The most spectacular results so far have been obtained with sintered aluminum powder. Since finely divided aluminum is always covered with a thin layer of Al_2O_3, the desired amount of oxide can be introduced by controlling the degree of oxidation of the powder, and up to 20% of Al_2O_3 may be present in the finished product. Sintered aluminum powder (SAP) has been extruded into various shapes, and the process, in spite of its cost, is amenable to mass production. The room-temperature properties of this product are not as good as those of wrought aluminum alloys. As the temperature is increased, however, the

strength, and especially the resistance to creep, of the SAP alloys do not decrease very rapidly, and above about 575° F. the SAP alloys are definitely superior to wrought alloys. Obviously, these unusual properties have attracted the interest of the aircraft metallurgists who are concerned about the effect of temperature on structures at supersonic speeds. The use of SAP for compressor blades is also being investigated.

Study of the reasons behind the high-temperature strength of SAP has shown that the finely dispersed oxide phase plays an important role in reducing the rate of creep. The technique of adding an oxide phase having the right particle size and the desired dispersion in the matrix is being studied in various laboratories. If the results continue to be as encouraging as they now look, a tremendous expansion of powder-metallurgy techniques into the field of high-temperature materials may be expected.

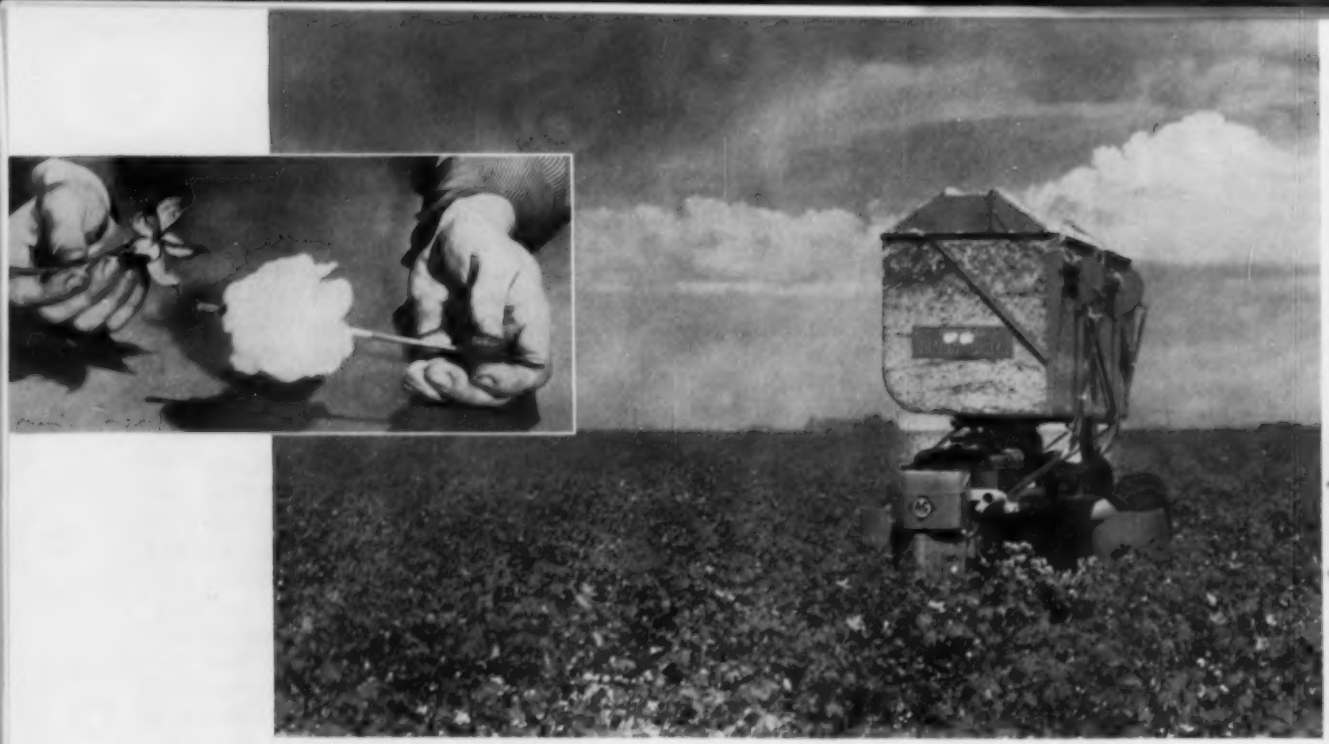
Structural Components—George A. Roberts, vice-president, technology, Vanadium-Alloys Steel Co., covered the wide subject of powdered metal structural parts. For a long time, one of the limitations of powder metallurgy has been its inability to produce high-strength parts. The development of techniques for producing pre-alloyed powders at reasonable cost has removed these shortcomings and it is now possible to manufacture powders with almost any alloy composition. Spur gears and cams are now mass produced from alloy powders of the S.A.E. 4600 series. Careful control of particle size distribution and shape gives the powder good molding characteristics and sufficient green strength for automatic handling. The shrinkage problem is comparable to that encountered with pure iron or bronze powders. Hardenability is the same as if the part had been cast or forged. Extensive testing of gears for pumps has demonstrated that without any sacrifice in performance, powdered gears made of high-strength alloy are more economical than cut gears having similar physical properties.

Corrosion resistant structural parts are made of a variety of powders whose analysis corresponds to the various standard types of stainless steels. Flake powders are widely used in paints and coatings. Another very important although more recent use of stainless powder is for industrial filters. These applications require considerable variations in the shape of the particles and in their size distribution. Irregularly shaped powder has better molding properties than spherical powders obtained by disintegration of a jet of molten metal. The spherical powders, which have a relatively high apparent density, are well suited for the production of filters made by the loose-powder or the dead-weight process. By close control of particle size, sintering temperature and sintering time, porous stainless steel shapes can be made with predetermined porosity and permeability. Examples were given of large porous sheets for aircraft uses.

High-Temperature Brazing—George D. Cremer, Research Div., Solar Aircraft Corp., discussed the use of metal and alloy powders for high-temperature brazing and oxidation resistant coatings. Jet aircrafts and missiles require heat resistant assemblies in which these new techniques are used. Oxidation resistant coatings contain ceramic or metallic powders or both. Examples were given of the use of brazing powders, aluminum and aluminum alloy powders entering into the composition of a "ceramic slip" used for protecting a jet-engine nozzle diaphragm. Micrographic examination revealed that the adherence of the coating was due mostly to a diffusion zone between coating and base metal.

The use of alloy powders for brazing was illustrated by a precision assembly for the combustion chamber of an aircraft engine starter. An air-cooled starter vane-shroud demonstrated the application to a complex and precise sheet metal assembly. In this part the low-alloy steel base metal was protected by chromizing, using a ferrochromium powder. An important outlet for the metal powder producer is the metal honeycomb sandwich structure used in the aircraft industry for maximum strength-to-weight ratio. It was surprising to learn that 1 sq. ft. of honeycomb, 1 in. thick and with cells about ⅛ in. wide, requires more than 1/5 of a mile of brazed joints. The weight of brazing powder per square foot of finished product is far from negligible.

The diversity of subjects presented at this interesting meeting is proof that applications of powder metallurgy have reached into many fields of modern technology. The audience was most responsive and a lively discussion followed the formal presentation. Obviously many people came to this A.S.M. meeting to learn about the subject and, as usual, the so-called experts were not always able to answer some of the questions. This made them realize that in powder metallurgy, as in many other branches of metallurgy, there are tremendous opportunities for an ever-increasing research effort.



Cotton Picker

THE COTTON PICKER is among the most recent in the long list of developments in agricultural machinery that have done so much to remove the drudgery from farming. Mechanization started with the invention of the reaper, the first harvesting machine for small grain. In the years following, machines to replace hand labor in tilling, planting, and harvesting have been developed.

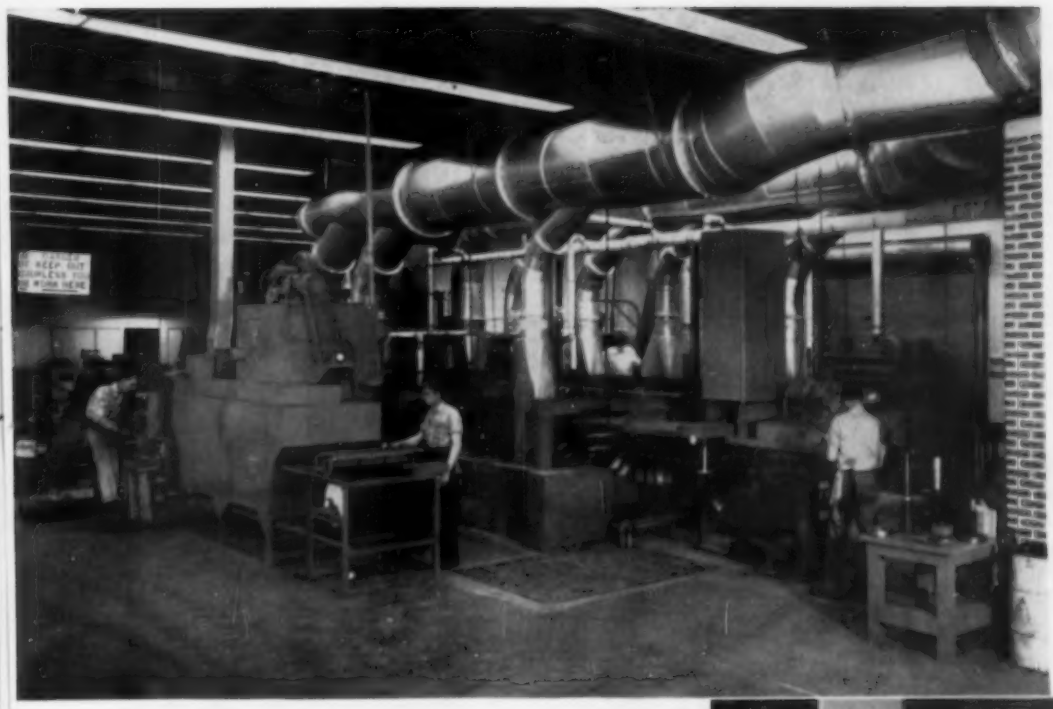
Although cotton has been an agricultural crop since the time of the Pharaohs and long ago we were able to mechanize its spinning and weaving into cloth, picking the cotton as it ripened progressively on the plants defied attempts at mechanization. The cotton plant is tough and sturdy and the boll coverings are sharp and rough so that picking is hard on the hands as well as the back. One approach to the problem was to develop a stripper, a machine which removed from the cotton plant all of the bolls, both ripe and green, as well as any leaves present. The mixture of ripe and unripe bolls gave a low quality yield that was not satisfactory even when the leaves were first removed by chemical treatment.

About 20 years ago, the rotating spindle shown above was developed. This device was the first and has proven to be the best for the selective picking of cotton – it possesses the ability to pick cotton from ripened, open bolls and leave green, unripened bolls to mature naturally. For the highest grade yield it is necessary to pick the cotton soon after the boll is open, before the exposed lint was weathered. With a selective picker several pickings can be made, just as with hand picking, to harvest the cotton in its prime. All pickers of this type in use today have such a spindle.

The development of this idea, the shape of the part, the manner of drive, and, of course, its method of manufacture, take various forms depending upon the ideas of those who have carried the development forward. Common to all, however, is the fact that the picking spindles rotate and are expendable. They must, therefore, be made at low cost in quantity for economical replacement.

One of the leading manufacturers of cotton pickers is Allis-Chalmers Mfg. Co., in a plant at Gadsden, Ala. Two thousand spindles per hour are produced there semi-automatically in the 30 × 60-ft. area shown above, right.

Annealed S.A.E. 1065 spring wire purchased in coils is straightened and cut into 8-in.



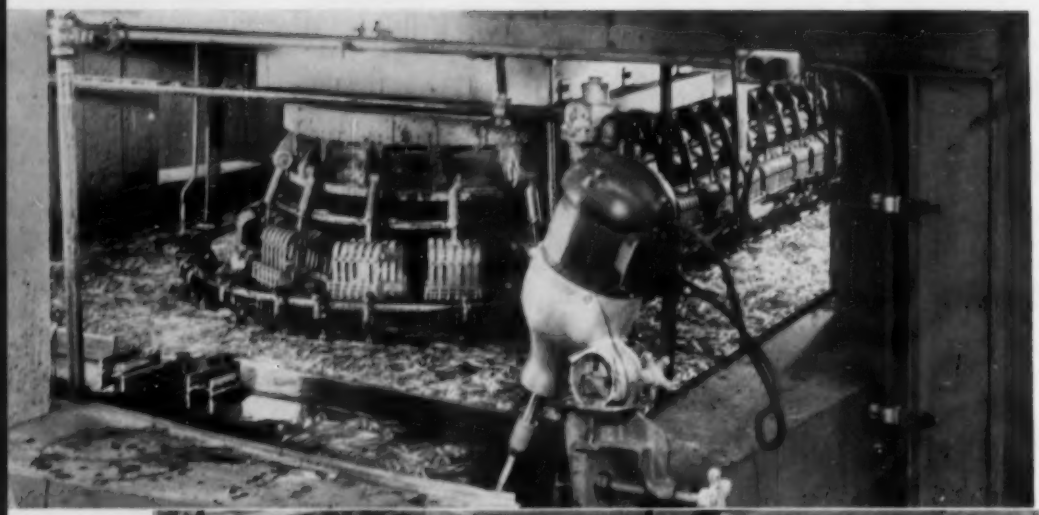
lengths to form spindle blanks (center view). The blanks are knurled for half their length in an automatic machine as the first step in producing a surface to grip fiber in opened bolls.

The knurled blanks are racked, degreased and hardened in a salt bath at 1575° F. (lower view). They are austempered at 600° F. to a final hardness of C-44 to 48. No hand straightening is required after hardening. The salt is removed by a hot water rinse followed by light blasting with slurry.

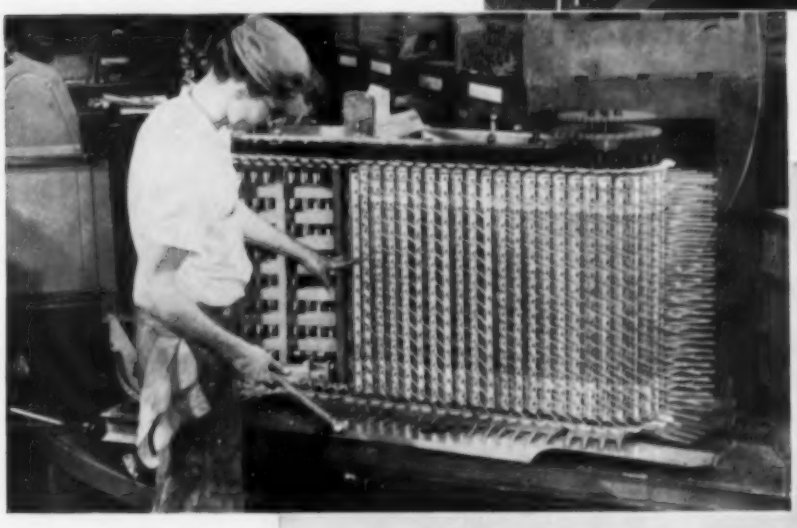
Chromium is plated 0.0002 to 0.0003 in. thick on the knurled portion of the spindles in the Lasalco continuous automatic plating line (p. 102). The plate is intentionally left rough so the spindle will seize the cotton fiber better.

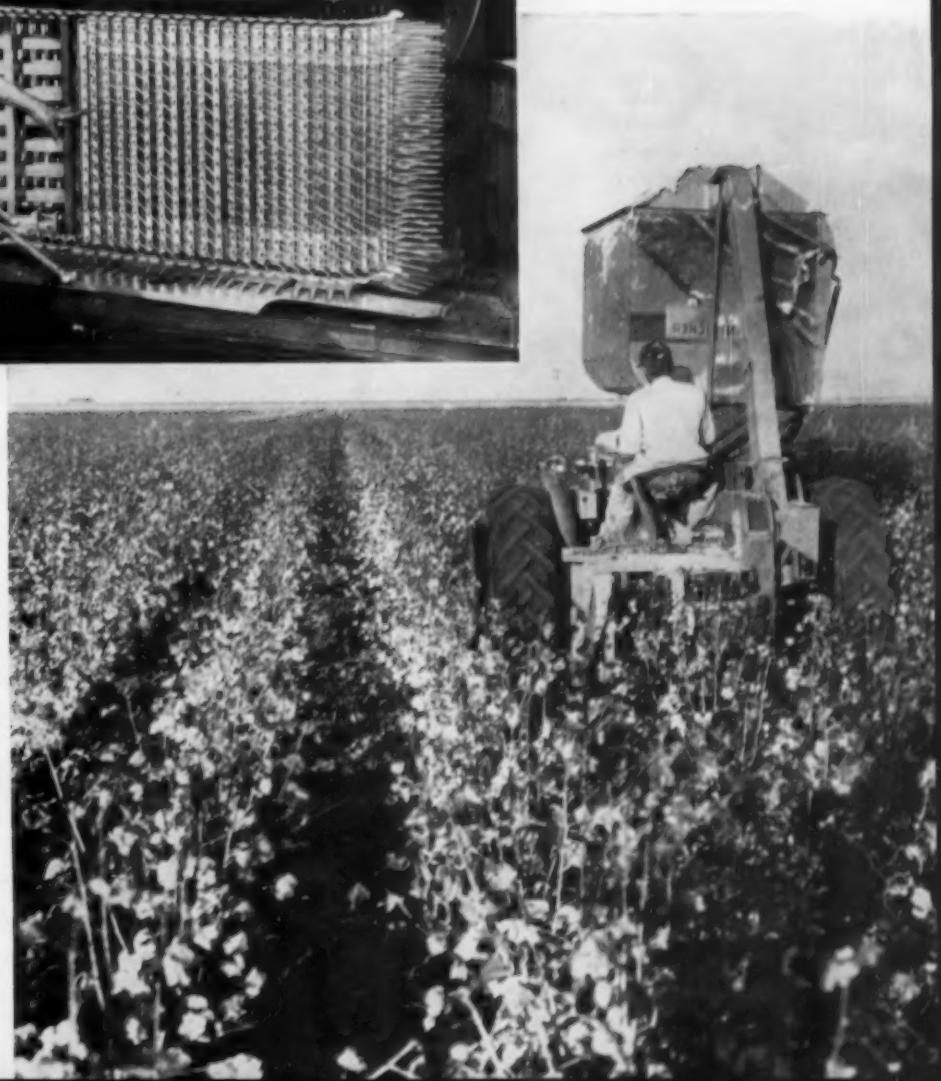
From the plating line the spindles are transferred to an oven where they are baked at 350° F. to eliminate hydrogen embrittlement. They are fed through on a continuous wire-mesh conveyer to assure fast, uniform heating to temperature.

A drive roller is pressed into place on the drive end of the spindle automatically, and the spindles assembled into carriers. The carriers are affixed to the picking heads and are ready to roll into action.



Rotating spindles for the Allis-Chalmers cotton picker are given a thin chromium plate in a continuous plating line, then baked to prevent hydrogen embrittlement (sequence at left). Final step is the assembly of the spindles to the carriers (right), and the carriers to the picking heads (below); then on to the cotton fields.





"Atoms for Peace" Program

Two New Proposals for Participation by Free Nations*

ON THIS campus this morning I had the privilege of inspecting the first atomic reactor of its kind established under university auspices. This reactor facility was made possible by the foresight of the trustees of the university who financed the structure and its operation. The Atomic Energy Commission provides only the fuel. In consequence, within several weeks, the atom will be at productive work here at Penn State. Here also the economic and human problems created by this new energy will be simultaneously studied by the distinguished faculties of this institution of learning.

Our nation has no desire for a monopoly on the knowledge and practice of these possibilities. We want the world to share — as we always have.

For maximum progress in the future, we must work for a continued partnership between the world's best minds — in science, engineering, education, business and in the professions.

Already we have made substantial progress under Congressional authority toward agreements with friendly foreign governments for participation with us in the task of forwarding peaceful atomic progress. Now we move into further action.

We have developed two new programs that I shall submit to the Congress in the conviction that they reflect the spirit and intent of law and of the American people.

First, we propose to offer research reactors to the people of free nations who can use them effectively for the acquisition of the skills and understanding essential to peaceful atomic progress. The United States, in the spirit of partnership that moves us, will contribute half the cost. We will also furnish the acquiring nation the nuclear material needed to fuel the reactor.

Second, within prudent security considerations, we propose to make available to the peoples of such friendly nations as are prepared to invest their own funds in power reactors, access to and training in the technological processes of construction and operation for peaceful purposes.

If the technical and material resources of a single nation should not appear adequate to make effective use of a research reactor, we would support a voluntary grouping of the resources of several nations within a single region to acquire and operate it together.

The research reactors acquired under this program will be fertile seeds for progress sown in the receptive soil of the free nations. The cost to the people of the United States will be small indeed when measured against the certain returns, tangible and intangible.

The second proposal will be of immediate interest mainly to the power-short areas of the world where atomic power may be economically feasible even today. Some of the countries, however, lack the knowledge and experience needed to construct and operate a commercial power reactor. This we can share for constructive purposes with friendly countries without real risk to our national security. Such sharing is expressly contemplated by the new Atomic Energy Act.

Together, these two provisions are designed, within the limits of prudence, to clear away some of the obstacles that have impeded progress in nuclear science to permit its peaceful application by all who propose to make it serve mankind.

The people of the United States instinctively reject any thought that their greatest scientific achievement can be used only as a weapon. Our increasing progress in its peaceful applications is evidence of that fact.

The U.N. as an Instrument of Peace†

A decade ago the Charter of the United Nations was signed by its 50 founding members. Into a world, shattered and still at war but hopeful and eager for a new dawn, was born an international organization, fashioned to be the supreme instrument of world peace.

I reaffirm to you the suport of the Government of the United States in the purposes and aims of the United Nations — and in the hopes that inspired its founders.

In so far as our technical, material, and intellectual capacities permit and wherever our aid — including the peaceful use of atomic energy — may be needed and desired, we shall continue to help others achieve constantly rising economic levels.

The object of our second decade is still peace — but a peace of such new kind that all the world will think anew and act anew.

It cannot be a mere stilling of the guns — it must be a glorious way of life. In that life the atom, dedicated once as man's slayer, will become his most productive servant. It will be a peace to inspire confidence and faith so that all people will be released from the fear of war.

Scientists will be liberated to work always for men, never against them.

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*Excerpts from President Eisenhower's Commencement Address at Pennsylvania State University, June 11, 1955.

†Excerpts from the President's address at the United Nations anniversary meeting in San Francisco, June 20, 1955.

Lifting capacity of this Austin-Western crane was increased 350% by replacing cylindrical worm gearing with Cone-Drive gearing. The boom lifting mechanism is driven by a 6" center distance 50:1 Cone-Drive Gearset powered by hydraulic motor. A similar 5" center distance 40:1 Cone-Drive unit swings the crane.

350% more lifting capacity with help from nickel alloys

DON'T ADD BULK or deadweight to increase load capacity.

Cone-Drive gearsets that raise and swing the boom of this crane show how you can strengthen an assembly while making it more compact.

Cone-Drive mates a nickel alloy steel worm with gearing of chill-cast nickel alloyed bronze. Added to bronze, nickel imparts extra life and strength, raises elastic properties, and increases shock resistance as much as 25 to 50 per cent.

Likewise, nickel contributes much to the worm. Cone-Drive worms are medium-carbon nickel-chromium-molybdenum steel, heat treated to a minimum hardness of 32 Rockwell C and 140,000 psi tensile strength.

The nickel content in this steel helps make possible a surface that resists wear and spalling . . . and a core with the toughness to withstand severe overloads.

In many a metal, you can improve specific properties by use of nickel alone or in combination with other alloy elements. When you have a metal problem, whatever the difficulty, send us details. We'll be glad to give you suggestions based on our wide experience in this field.

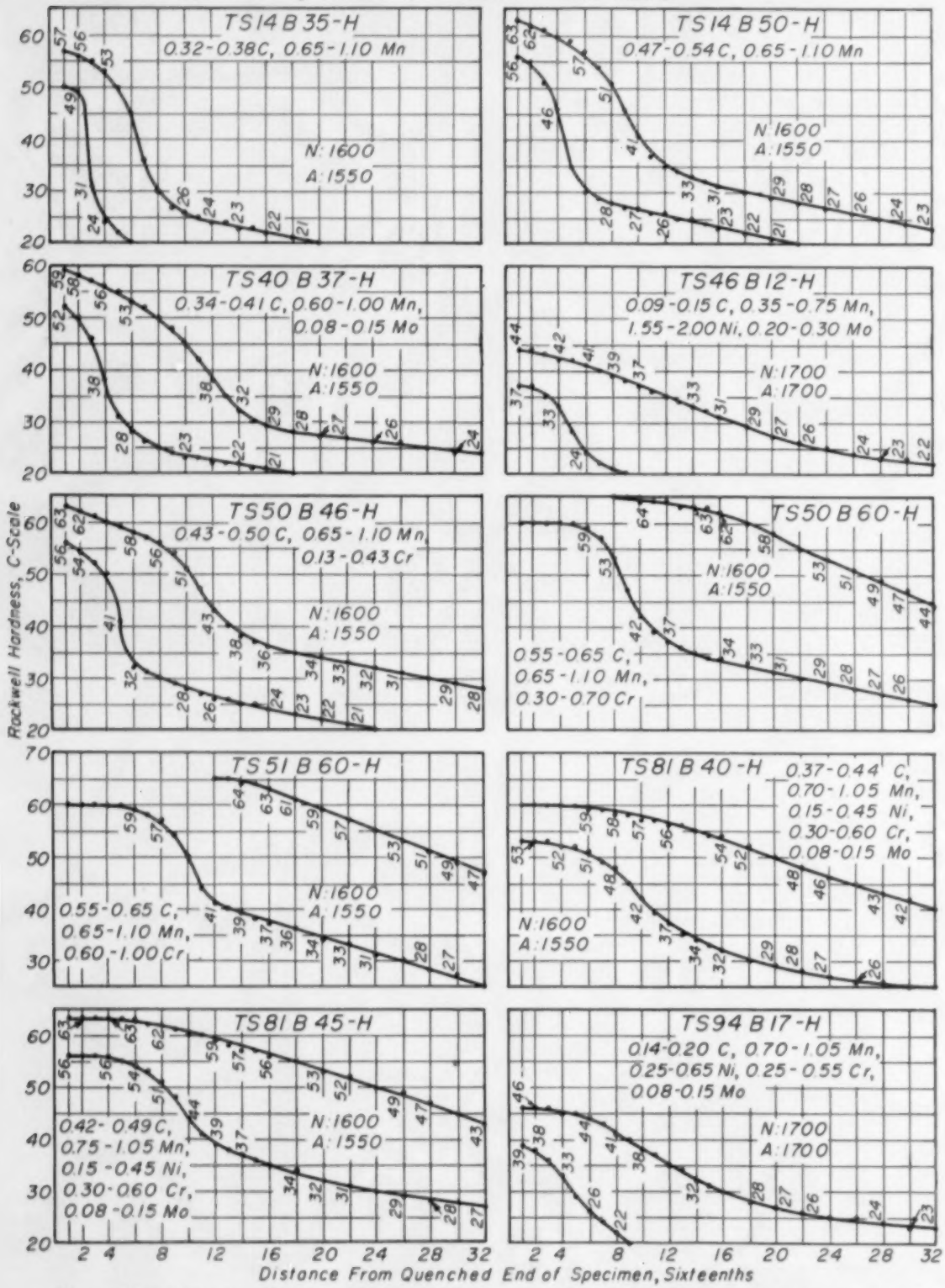
Give compact units stamina by designing to use high mechanical properties of nickel alloys. Above is such a unit, produced by Cone-Drive Gears Division of Michigan Tool Co., Detroit 12, Mich.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.

Tentative Standard H-Steels, Boron-Treated

A.I.S.I. list of February 1954.

All boron-treated steels may contain 0.20-0.35 Si and 0.0005 min. B



N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.).

Hardness limits are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.

For warp-free heat treating...

Craftsman Rotary Power Lawnmowers are sold exclusively by Sears, Roebuck & Co., and are made by Newark Stove Co., Newark, Ohio, a Sears subsidiary. Uniform heating in AEROHEAT 1200 and 300 baths prevents warping of carefully balanced blades during heat treatment.

Sears, Roebuck & Co. austempers rotary lawnmower blades to 42-50 Rockwell C in **AEROHEAT® 1200 and 300** *heat-treating compounds*

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New Developments in Metallurgy

*By BRUCE S. OLD**

Since 1938 metllurgists have been in part responsible for major advances in nuclear energy, gas turbine development, electronics, steel melting and many other fields. They have in turn benefited from the interchange of ideas with other branches of engineering which also have contributed to these developments. (Ageneral)

LET US suppose that a brand new graduate student had been isolated from metallurgy since 1938 and suddenly came back into the picture in 1955. What changes would he see? The changes I will discuss will sound not like a careful, chronological historical treatise, but rather mixed up, since they revolve around some personal experiences. I hope that they will give a diversified picture with the proper perspective.

At about the time of my graduation in 1938, the physical chemists and chemical engineers started to invade the field of process metallurgy in force. The more empirical or "cook book" methods started to go by the board. People like K. K. Kelley of the Bureau of Mines, Herty, Chipman, Darken, Larsen, E. Smith, and others, through their contributions to the knowledge of equilibria and rate phenomena, had revolutionized our understanding of the openhearth process. The black book in the hip pocket of the openhearth superintendent, the first carefully guarded top secret document I ever stole a glance at, was in vogue in 1938, when I first spent some time in an openhearth shop. Within the space of three short years, a tremendous change occurred. Not only did physical, chemical and thermodynamic knowledge of slag-metal reactions suddenly spread, but the chemical engineers were improving combustion systems and instrumentation, and the ceramists were adding new and better brickwork and construction methods to the openhearth. The black book became obsolete, and the openhearth superintendent suddenly found himself carrying around all sorts of graphs of deoxidation rates and slag-metal equilibria. He also found himself studying chemistry and even helping to write the current and best text, *Basic Open Hearth Steelmaking*. Thus, better control of metal analysis and greater tonnage per hour were soon achieved. I can well remember that, when I went to Sparrows Point in 1939, it was normal to make two heats per furnace per day; but when Mr. Wheaton, an early Charlie Herty convert, really started to push a furnace with all the new-found knowledge, he was able to get an amazing average of three heats per day

*Vice-President, Arthur D. Little, Inc., and President, Nuclear Metals, Inc., Cambridge, Mass. Based on a talk given at Pennsylvania State University, University Park, Pa., at an A.S.M. meeting.

The Jet Tapper, Which Has Proved so Useful to Steel Melters, Is One of the Many Byproducts of Discussion Between Mathematicians and Metallurgists

for one month, and on two days actually got four heats per day. Such feats really sold the technical approach.

Despite diverse signs of the awakening of what I propose to call the sleeping giant of the science of metallurgy, at the start of World War II metallurgy was considered strictly as an art by the great scientists. In fact, as far as I know, only one metallurgist, Paul Merica, was really in the scientific fraternity. He had been honored with election to the National Academy of Sciences as a result of his pioneering work on age hardening. The proof beyond doubt of the low position in science held by metallurgists was the position given them in 1941 when, with war imminent, the National Defense Research Committee was formed. Originally, the N.D.R.C. had four main divisions, and metallurgy was just a small group of three men in a remote subdivision of Division B. To top it off, the head of the subdivision was not a metallurgist, but a chemical engineer, Warren Lewis of M.I.T.

In August 1941, a green reserve ensign who had just been ordered to active duty inadvertently played a role in changing this situation. His honored boss, Jerome Hunsaker, co-ordinator of research and development for the Secretary of the Navy and chairman of the N.A.C.A., believing that the role of metallurgy during a war should be of vital importance, gave this ensign as his first assignment the task of investigating this matter. After a brief period, the ensign walked with trepidation into Dr. Hunsaker's office and began to make his oral report. As soon as the first halting sentences criticizing the pitifully insufficient N.D.R.C. effort fell from his mouth, Hunsaker picked up the telephone and started to dial. The ensign stopped, but Hunsaker said to keep talking since he was listening carefully. As the ensign droned on, the telephone connection was made and the following long conversation ensued: "Bush? Say, Van, metallurgy in the N.D.R.C. stinks and something has to be done about it immediately." Bang went the receiver. The ensign wavered like a reed and staggered out of the room. Thus, by the foresight of a distinguished aeronautical engineer, the War Metallurgy Committee was born. Under the able leadership of Clyde Williams of Battelle, this Committee became a full-fledged division of N.D.R.C.

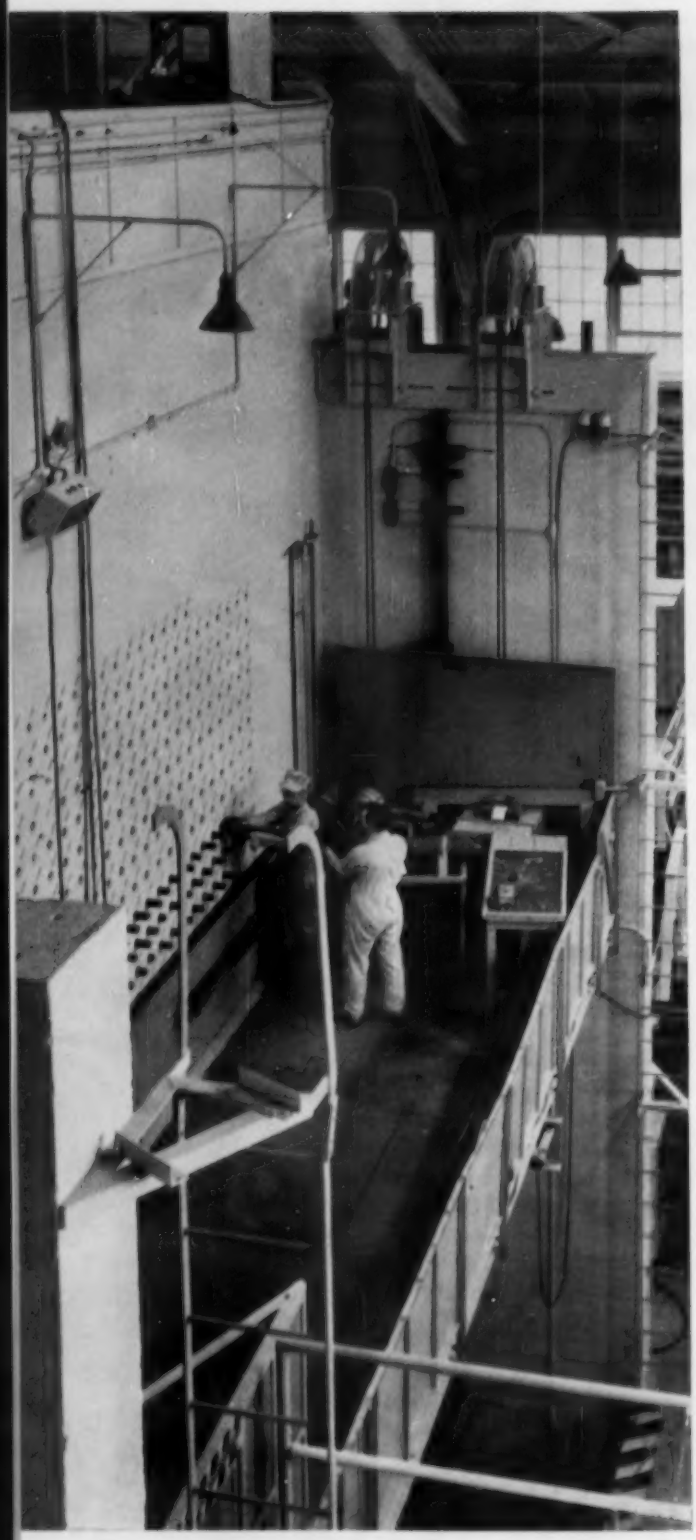
Work of the War Metallurgy Committee

The work of the War Metallurgy Committee, under the press of war, stirred the awakening metallurgical giant previously mentioned, and started a revolution in metallurgy. This revolution got under way for two reasons: first, because the urgent requirements of the nation thrust upon metallurgists both pressing demands for rapid strides in all areas of metallurgy and the funds to support the program; second, because of cross-fertilization between metallurgy and other sciences. As metallurgists were brought into contact with scientists from other fields, two things happened; the metallurgists absorbed knowledge, or had it stuffed into them, and the men from other fields developed not only an interest in the problems of the metallurgists but, in rare instances, a certain respect for the poor metallurgist and his endless, complex problems.

Radioactive Isotopes Are Used in Pipelines to Signal the Arrival of Different Oil Products

It is interesting to mention a few of the advances made under the general direction of the War Metallurgy Committee. Perhaps the most striking was in the field of heat resistant materials. In 1941, the possibilities in jet propulsion of aircraft and in gas turbine ship propulsion were just a gleam in the eyes of a few. But the aerodynamics experts on the N.A.C.A. subcommittee on jet propulsion, realizing the potential importance of sonic speeds in aircraft, pushed the metallurgists into undertaking the development of improved heat resistant materials for both turbine buckets and compressor blades. Without the high efficiencies brought about by improvements in aerodynamic and thermodynamic factors, gas turbines would not be practical. The aerodynamicists did their part, and the metallurgists also came through handsomely. A tremendous cooperative attack, involving approximately ten industrial firms and six university and government laboratories, was made on the problem. The British also had teams working. The basis of the initial program was iron-base alloys; however, an emphasis on nickel, cobalt, and chromium ultimately reduced iron to the status of an impurity. Cross-fertilization of the metallurgists with aeronautical and mechanical engineers, chemists, and mathematicians soon got into high gear to such an extent that the screening of hundreds and hundreds of new alloys, improved casting methods, better heat treatment, superior grain-size control, and new evaluation programs finally made the gas turbine practical. Thus, in the remarkably short space of three years, operating temperatures of turbine buckets were raised from the impractical temperature level of 1100° F. to the feasibility temperature of 1400 to 1500° F.

Another area of work involved increasing production in the steel industry. Here again, exchange of ideas – this time among chemical engineers, physical chemists, and an expert in petroleum refinery plant design – assisted the process metallurgists in the practical development of an increased output of blast furnaces through the use of high top-pressure operation. I shall only mention two things in connection with this achievement. First, much of the credit for the success of high top-pressure blast furnace operation goes to the late Joe Slater of Republic Steel, who volunteered to make the first installation and who pushed the development with pioneering zeal in the face of numerous difficulties. Second, a high top-pressure furnace has



Workmen Shown Removing Plugs From Fuel Channel Opening in the Shield of the Oak Ridge Graphite Uranium Reactor

recently set an all-time U.S. record, for U.S. ore (without scrap charge), of 1573 tons per day average production for one year.

To give the metallurgists their due, it is only fair to state that a splendid job was done during the War on the so-called N.E. (National Emergency) steels in a program guided by John Mitchell. These permitted alloy conservation and substitution of such metals as Ni, Cr, Mo, Mn, V, and W. During the war the alloy availability picture changed once a week, and our hard-working steel plant metallurgists developed an ability to roll with each new punch.

And, finally, just to keep everyone from getting too cocky, it might be said that we had our problems with brittle failure in ship construction and that, despite 14,381 lb. of interesting reports, we still do not know many of the answers.

In 1941, another event occurred which had a profound effect on the growth of metallurgy as a science. In that year, it was decided to push the development of the atomic bomb. It is interesting to note that the nuclear physicists, mathematical physicists and chemists who spearheaded this program decided that the biggest bottleneck in the program was metallurgy. Thus, metallurgical laboratories were quickly established at the University of Chicago, Massachusetts Institute of Technology; Ames, Iowa; Oak Ridge, Tenn.; and Los Alamos, N.M.

Here the metallurgists were put to the extreme test. Men like Oppenheimer, Fermi, Wigner, Bethe, Bohr, Cockcroft, Compton, Teller, von Neumann, Lawrence, Rabi, Alvarez, Conant, Bush, Tolman, and Seaborg almost looked down their noses at the poor metallurgists – who were rated, initially, on about the same level with a U.S. Navy Cook, 2nd Class. But, with the help and constant needling of all other branches of science, the metallurgists dug in and went after the problem with a vengeance. As a result, the atomic bomb became a reality. It was not easy. At the start, not even the melting point of uranium was known, and only milligrams of plutonium had ever been produced. Yet in two years nuclear reactors, involving uranium fuel elements, and diffusion separation plants were operating, and the metallurgy of plutonium and uranium was advanced to the stage where both the plutonium and uranium bombs were in the

works. This represented the compression of the ordinary time for research and development at least tenfold. It also brought about the recognition of the growth of metallurgy into an area of science in the eyes of the mightiest of the world's scientists. Partial credit is due to the metallurgical group at Los Alamos under Cyril Smith, which included Balke, Baker, Jette, Marshall, Schoonover, Seybolt and Taub, to mention a few. The metallurgy giant was finally in a sitting position.

Following the end of hostilities, two important developments took place with respect to the future of metallurgy. First and foremost, it was recognized within the same small office of the Coordinator of Research in the Navy Department that a continuity of relations between top scientists and the national defense effort was required if this nation were to survive. Thus was born the Office of Naval Research; the Congressional Act which set up this agency, incidentally, was written by two still-green reserve lieutenant commanders. The first trip around the country to sell the top scientists of the nation on accepting Navy contracts for fundamental research was made late in 1945. Fortunately for the United States, it turned out to be successful. The prewar research effort in fundamental metallurgy was completely dwarfed by such postwar figures as 54 projects in progress with a budget of $1,350,000 for 1954.

The second great event was the establishment of the Atomic Energy Commission. In it was set up the division of research, and in that a branch having to do with metallurgy and materials. This group also launched an extensive program in basic and applied research. In each of the last four years about $1,500,000 has been spent outside national laboratories on programs carefully selected to broaden our knowledge of metallurgy and materials.

This dual support by the Defense Department and the A.E.C. of fundamental metallurgy is evidence of the importance attached to the future of metallurgy by the nation. This financial assistance has been a strong motivating force in bringing about a tremendous stride forward in the solid-state field. Thus, men like Seitz, Slater, Cyril Smith, Cohen, Shockley, Warren, Duwez, Reed, Orowan, Mehl, Fisher, Hollomon, Averbach, Clark, Lawson, Smoluchowski, Gensamer, Turnbull, Zener, Siegel, Brokker, and a host of others, have helped, through basic work done with this assistance, to make metallurgy a quantitative rather than a qualitative science.

Let us look briefly at just one of the more glamorous areas of recent solid-state development, the work on transistors. At the Bell Laboratories, fundamental work in physics by Bardeen and Brattain in 1948 on studies of holes and electrons in germanium and silicon crystals led to the development of the transistor by Bill Shockley in 1949. The transistor is a small, single crystal of germanium (3 to 4 mm. long by 1 mm. square) of high purity, made by carefully controlled fractional recrystallization, followed in some instances by the addition of very small quantities of donor atoms (which donate electrons) or acceptor atoms (which create holes). The transistor is the most remarkable amplifier of small electrical signals ever made. It operates at power levels of 1/1,000,000 watt (1/1,000 of smallest vacuum tube), has no warm-up time, requires no cathode heater power, is rugged, is free of microphonics, and has an indefinite life.

Metallurgical Problems of Atomic Energy

Now a quick look at what has happened in the atomic energy field since the end of the war. For a number of reasons obvious to all, let us avoid weapons talk and stick to reactors and peacetime uses.

At the outset, the metallurgist is once again confused and fogbound. Even such a familiar phenomenon as time is spoken of not in terms of seconds or hours, but as shakes. If the lowly metallurgist stops to think about this term, he rapidly deduces that a shake obviously has something to do with the old expression, "as quick as a shake of a lamb's tail". This particular shake turns out to his surprise to be defined as 10^{-8} seconds. The metallurgists' woes have only begun. Raw materials, such as uranium, are so scarce that "ore" is 50 parts per million stuff, requiring Ph.D.'s in physical chemistry to concentrate and purify it without ruinous losses. Others, such as beryllium and thorium, present similar problems.

Next, let us look at the guts of the reactor; namely, the fuel element. Within the fuel element, fissions occur in a random fashion. At each fission location, "temperatures" of the order of 7.8×10^8 degrees Absolute occur; then the area is "instantaneously" quenched by the surrounding metal. Here, the chain reaction occurs, and the fuel element must be made up in part of one of the three fissionable materials: U^{233}, U^{235}, or Pu^{239}. We shall ignore plutonium other than to say that its properties rhyme with its chemical designation, Pu. And uranium is essentially no better. Any

self-respecting industrial metallurgist of 1938 would take one look at uranium and recommend strongly to his boss that the material be abandoned and a substitute found. Unfortunately, we have no ersatz fissionable material, so that the metallurgists of the atomic era are stuck with it. It is to their everlasting credit that they conquered the metallurgy of this rotten metal in an incredibly short time in so effective a manner that reactors built ten years ago are still operating.

Today, in designing and constructing new fuel elements, the metallurgist receives a broad education; he must cooperate with other scientists in considering fissionable alloys, fabrication, power ouput, temperature, external applied load, residual stresses, thermal stresses, heat resistant properties, burn-up, radiation effects, phase stability, heat transfer, corrosion and erosion resistance, remote handling, neutron characteristics, fuel and fission product migration, canning, testing, and, finally, cost. This has forced a tremendous amount of research on new alloys and new materials such as zirconium and vanadium. Reactor coolant problems have also forced much metallurgical research in the field of liquid metals as heat transfer media.

Time may finally prove that the greatest benefit to mankind from the development of atomic energy will come not from the nuclear power business, but from the use of radioactive tracers in research. Despite the fact that radioactive tracer work started long ago, it was known only to a few physicists, and was not taught to the metallurgy student in 1938. Actually, tracer work was begun as long ago as 1911, when Hevesy and Paneth, separately, tried for two years unsuccessfully to separate radium-D from lead. (It was really a then-unknown isotope of lead.) It suddenly dawned on both that they had discovered the possibility of utilizing radioelements as tracers, and published a joint paper in 1913 to this effect. Tracers in 1938 were expensive and rare. For instance, a millicurie of carbon-14 produced by cyclotron bombardment would have cost about a million dollars. But the advent of the A.E.C. and the isotope production program has brought the cost down to about $50. Also, tracers became rather everyday talk among physicists, chemists, and metallurgists, so that cross-fertilization was acting in a beneficial way again. All sorts of metallurgists became familiar with the Segre chart. With 450 induced radioisotopes known, at least one for each of the 96 elements, the work of the A.E.C. made tracer work an economical and feasible tool. From a fundamental point of view, the use of tracers in the study of diffusion in metals has been of great significance in the study of the solid state. Other uses have been in studying corrosion, electroplating, sources of impurities, and wear.

It should now be obvious that the metallurgy student of 1938 would be completely lost, as I am, if he were suddenly confronted with the metallurgy of today.

The challenge ahead is such that one can accurately say that only the surface has been scratched. I have termed metallurgy an awakening giant. Why a giant? Few scientists stop to consider that 75 out of the 96 elements are metals. In 1938, only 21 of these were fairly well known. Since then we have added some knowledge of uranium, thorium, plutonium, beryllium, titanium, chromium, cobalt, zirconium, germanium, gallium, molybdenum, hafnium, and polonium. Work has also been done with the help of the chemists on gadolinium, lanthanum, cerium, prasodymium, columbium, neodymium, vanadium, dysprosium, erbium, ytterbium, samarium, holmium, thulium, yttrium. But much remains unexplored in a field unimaginably vast.

The basic knowledge of the solid state and the thermodynamics of metal systems are just getting to the point where theory is beginning to lead the art in metallurgy so that quantitative predictions are becoming possible. Forward strides, probably far beyond our current dreams, can and will be made in the days to come.

Cross-Fertilization of Sciences

It is my belief that this growth of metallurgy from an art to a science is the result of cross-fertilization of metallurgy with other sciences such as physics, chemistry, mathematics, engineering, and electronics. This cross-fertilization was brought about by the rugged requirements of World War II, by the recent extensive growth of support of research by government and industry, and by the increased realization on the part of all scientists that the fate of the nation depends in large measure on our having available better materials than any potential enemy.

In emphasizing again the importance of cross-fertilization, I would like to relate one last story on its benefits. I know a dumb metallurgist who one day during the war had the assignment of entertaining the great G. I. Taylor, who was visiting from England on atomic business. He (the dumb metallurgist) arranged a meeting

Guided Missiles Like the Matador Offer New Metallurgical Problems in the Trans-Sonic Field

with the celebrated Johnny von Neumann, one of the top mathematicians of the world, and the three sat down at a conference table. The subject was how to calculate the forces of action in the explosives phenomenon variously called Munroe effect, cavity, or cone-shaped charge. Von Neumann had a series of 55 equations and 56 unknowns and was seeking Taylor's assistance. Taylor had previously solved the equations, but could not recall how he had done so; so that a long discussion ensued. The metallurgist provided no assistance, I can assure you. Yet five years later, the same metallurgist (then playing with metallurgical furnaces) saw his oldest son eating an ice cream cone, got a flash that said: "shaped charge – Taylor – von Neumann – lousy furnace-tapping methods", and out of it all came the jet-tapper development. This is now used all over the country to tap openhearth furnaces. That is cross-fertilization at work. Let us as metallurgists realize the importance of this and foster it further.

At this point, it is proper that a statement be made concerning the progress of Russia in metallurgy. A review of Russian physical metallurgy literature indicates that it is as interesting as any contributions being made currently by any other country. In production metallurgy, the same is true. Anyone who takes comfort in saying that Russian science is good, but its technology is poor, can be given a rude shock by noting that the Russian blast furnace men have at least 11 high top-pressure furnaces operating effectively; that Russia produced the atom bomb in essentially the same elapsed time that the United States did; that Russia produced the H-bomb as rapidly as did this country; and that Russian jet engines are both excellent and mass produced.

This nation faces a great challenge. The progress of the science of metallurgy in the United States has a paramount role to play in preserving the democracy of the world. It is my hope that students may be inspired to continue to push on, in the face of any difficulties, the coordinated effort to fully awaken our giant, and to keep this nation in the forefront with respect to both civilian and military metallurgical advances. In this way, we can do our part in assisting those humble persons in Washington who daily face the overwhelming responsibilities and problems of maintaining the independence of this nation in a troubled world.

Teflon-Impregnated Bearings for Service in Water

*By H. B. NUDELMAN and CORD H. SUMP**

Porous stainless steel bearings impregnated with Teflon are recommended for service where hot water is used for lubrication. (T7, SS)

Most conventional bearing materials are not effective under water lubrication because of the disastrous corrosive action of water, particularly when warm. Since water is the only lubricant that can be used in some equipment of the Atomic Energy Commission, a search for new bearing materials was undertaken through the Westinghouse Atomic Power Div., Westinghouse Electric Corp.†

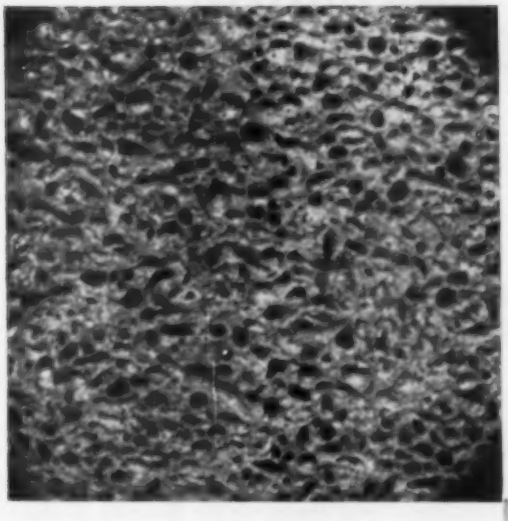
Du Pont Teflon (polytetrafluoroethylene) has the necessary chemical properties to recommend its use in heated water and has the desired antifriction properties. It is reported to be stable to 500° F. and inert to all common corrosive agents except the alkali metals. The corrosive action of heated water does not affect Teflon. However, Teflon flows under load at elevated temperatures, preventing its use as a bearing material by itself. A metallic skeleton appeared to be an effective method for confining the Teflon and making a shock resistant aggregate. Bodies having this combination of properties are rather new and appear to be useful. This article gives the highlights in their development.

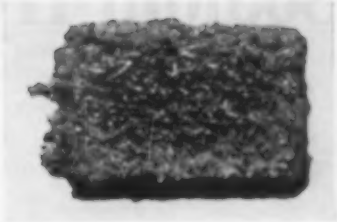
A low coefficient of friction results, in general, if a film of low shear strength runs against a hard surface. When Teflon is smeared on metal surfaces, favorable frictional properties result, but these eventually disappear when the Teflon wears away. To avoid this difficulty, F. P. Bowden in 1950 impregnated porous sintered copper with Teflon and found that the aggregate slid over steel surfaces with low friction at temperatures up to 626° F.

Bowden's work initiated a promising method of using the desirable properties of Teflon by supporting it in a metallic framework. The metal

*Respectively Assistant Metallurgist, and Supervisor, Powder Metallurgy Research, Armour Research Foundation of Illinois Institute of Technology, Chicago.

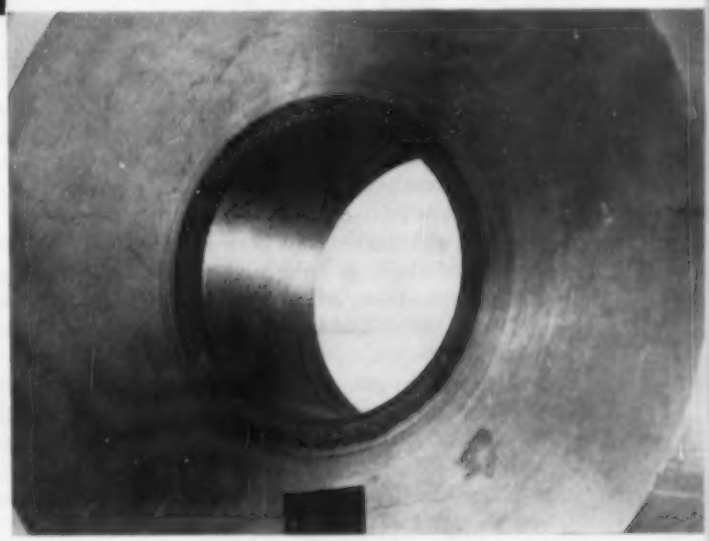
†Contract No. AT-11-1-GEN 14, Subcontract 14-309 Task III.





Fractured Surface of a Teflon-Impregnated Stainless Steel Compact. 4×

Structure of Teflon in a Porous Stainless Steel Bearing. The pits and holes represent areas from which stainless steel has been removed by HCl



Teflon-Impregnated Stainless Steel Bearing in Housing. Actual Size

would prevent excessive flow of the plastic and possibly provide a reservoir to supply Teflon to the surface for renewal of the lubricating film. It would also provide shock resistance and strength. The bearing metal matrix has to withstand corrosion at 200° F. in oxygenated water, so it is necessary to prepare porous bodies of a corrosion resistant alloy by powder-metallurgy techniques.

For test purposes, Bowden impregnated porous copper to an estimated depth of 1 mm. In the present work, heavy concentrations of Teflon are produced 3 to 4 mm. deep by multiple impregnations; below this point the amount of Teflon decreases as the depth increases. Deeper impregnation is used so that Teflon might be supplied to the surface more readily as it is worn away during bearing operation.

Type 440 A stainless steel powder is suitable as the matrix for the bearings. Grain hardness values in the range of Rockwell C-50 are obtainable by heat treatment, and the impact resistance shows a 9 to 18-fold increase over carbon. With Type 304 stainless steel, much greater ductility is obtained. Special machining techniques are required to avoid surface metal smearing during bearing preparation.

The bearings were mated to hard chromium-plated shafts and tested in water at 200° F. No wear or corrosion was noted at the conclusion of the tests, which extended up to 309 hr. at a pressure of 99 psi.

Summary – The presence of a continuous film of Teflon on the wear surface of test bearings prevents metal-to-metal contact. The porous metal structure is able to hold the Teflon yet permit its service as an antifriction agent. Greater surface porosity and a continuous Teflon network might result in higher running loads. The stability of Type 440 A stainless steel in these test environments indicates that the Teflon film contributed a measure of corrosion protection to the porous metal. The metal-Teflon bearing might find additional utility in thrust bearings where lubrication can be inadequate under start and stop conditions.

Sodium Hydride Descaling of Titanium

*By W. J. BARTH and A. L. FEILD, Jr.**

When sodium hydride is used to descale titanium, hydrogen will be absorbed by the metal as soon as the scale is entirely removed. (L12, Ti)

MUCH EFFORT has been expended in attempts to find suitable descaling methods for titanium metal. Acid techniques are ineffective. The sodium hydride process has been used commercially for many years for descaling stainless steel and, since 1949, has been applied to titanium; however, it has limitations. To determine the limitations, titanium samples were descaled in a laboratory hydride unit functioning in a manner similar to practices in industry.

Objectives included the establishment of the behavior of commercially pure titanium during actual descaling, and during the metal attack that follows. Observations were made of scale and base metal attack rates, hydrogen absorption from the bath during metal attack and the effect of hydrogen on bend characteristics.

The rate of scale solution is primarily a function of bath temperature, scale type and thickness. The rate of metal attack is a function of bath temperature and is independent of sodium hydride concentration in the range of 0.7 to 2.5%. Hydrogen absorption does not occur to any measurable extent during the actual descaling period. Once metal attack is initiated hydrogen diffuses into the base metal. With bath temperature constant, hydrogen absorption is related to the amount of metal attack and the NaH concentration. The relationship between hydrogen absorbed and weight loss by metal attack is complicated by the effect of gage of the material and the temperature of descaling.

Excellent descaling can be accomplished using sodium hydride, but an optimum time-temperature cycle must be established to suit the scale characteristics of the particular titanium product being descaled. In all cases, immersion past the completion of descaling should be avoided to minimize hydrogen absorption. The work also infers that low NaH concentrations are preferred. Bend tests do not satisfactorily evaluate effects of hydrogen absorption.

Test pieces used in the study consisted of two heats of commercial grade sheet of 70,000 psi. minimum yield. Surface scale was that resulting from the mill practice on hot rolled annealed sheet of two suppliers. In addition, several forged and annealed bars were prepared from commercially pure round stock available in the laboratory. Properties of materials before testing are listed in Table I.

Approximately 50 coupons 2 × 3 in. were sawed and solvent cleaned without loss of scale.

Table I – Properties of Commerical Sheet, as Received

	SAMPLE A	SAMPLE B
Composition		
Iron	0.44%	0.43%
Nitrogen	0.077%	0.059%
Hydrogen	65-75 ppm.*	100-110 ppm.
Gage, in.	0.060	0.045
Bend, 75° included angle†	2½ T	½ T
Rockwell hardness	B-105	B-97
Scale characteristics		
Thickness (microscopic), in.	0.0003	Not measurable
Thickness, g. per sq. cm.‡	0.0035-0.0040	0.0005 approx.
Appearance	Heavy, brown	Thin, iridescent

*Hydrogen value the same whether the sample is belt descaled or has the scale intact.

†T = radius of bending die ÷ sample thickness.

‡Estimated from descaling data.

*Metallurgical Engineer and Metallurgist, Respectively, Pigments Department, Research Div., E. I. du Pont de Nemours & Co., Newport, Del.

Table II – Experimental Descaling Data

Run	Temp.	NaH	Time		Weight Loss G. per Sq. Cm.*		Hydrogen Increase, Ppm. (d)	d/c × 10^{-4}†
			Scale Solution	Metal Attack	Total	Metal Attack (c)		
Sample A, 0.060-In. Gage, Scale 0.0035 to 0.0040 g. per sq. cm.								
1	700° F.	1.3%	5 min.	0	0.0031	0	n.d.§	—
			10	0	0.0037	0		—
			20	0	0.0037	0		—
			40‡	—	0.0040	—		—
2	715	1.2	5	0	0.0037	0	n.d.§	—
			10	—	0.0041	—	n.d.§	—
			10	10 min.	0.0048	0.0008	20	2½
			10	30	0.0061	0.0021	60	3
3	800	1.4	2‡	5‡	0.0045	0.0005	n.d.§	—
			2‡	10‡	0.0056	0.0016	20	1
			2‡	20‡	0.0077	0.0037	40	1
			2‡	40‡	0.0116	0.0076	110	1½
Sample B, 0.045-In. Gage, Scale Approx. 0.0005 g. per sq. cm.								
4	700	1.0	—	40	0.0022	0.0017	90	5
		2.5	—	40	0.0021	0.0016	130	8
		1.0	—	120	0.0040	0.0035	160	4½
		2.5	—	120	0.0045	0.0040	290	7

*Total weight loss includes scale and base metal loss. Metal attack equals total weight loss minus scale weight loss.

†Ratio of hydrogen pick-up to unit weight loss. ‡Approx. §Not detectable.

This was followed by hydride descaling which consisted of *(a)* sample weighing, *(b)* bath exposure, *(c)* water quench, *(d)* acid pickling for 15 sec. and *(e)* sample reweighing. Weight loss was thus established for combined descaling and pickling. A 25-lb. laboratory sodium hydride unit that duplicates plant facilities was used.

Twelve runs were made at temperatures from 680 to 800° F. Hydride concentration was varied from 0.7 to 2.5%. Four pertinent runs are reported in Table II.

A separate investigation disclosed weight loss and hydrogen absorption due to pickling alone. Pickle weight loss was found to be 0.0006 g. per sq. cm. in 15 sec., and no hydrogen absorption could be detected. The 15-sec. pickle was adequate to remove the thin sludge that deposits on the surface of titanium during descaling.

The pronounced difference in descaling rate of Samples A and B is shown in Table II and Fig. 1. At 700° F. the thick scale of Sample A was completely removed in about 40 min. Most of the scale is removed in 5 min. Below the outer brownish scale a thin blue scale appeared that was difficult to remove. The appearance of this blue scale was such that it was hard to determine when descaling had been completed. Careful observation of the sample behavior during acid pickling aided in determining the descaling end-point. Completely descaled samples exhibited a general evolution of hydrogen bubbles over the entire sample surface. Incompletely descaled samples liberated hydrogen at localized points. For these reasons scale weight is reported as ranging from 0.0035 to 0.0040 g. per sq. cm.

Table II illustrates the initiation of metal attack and hydrogen diffusion upon the completion of scale solution. For given bath conditions, metal attack rate is essentially linear with respect to time and primarily dependent upon bath temperature. With prolonged exposure there is an apparent deviation from linearity. Immersion periods of 120 min. were used merely to exaggerate hydrogen absorption.

The tests on sample B indicate that metal attack rate is independent of sodium hydride concentration. While it is difficult with the existing data to compare the A and B materials, it is seen that the metal attack of the 40-min. exposure of sample A at 715° F. is about the same as the 40-min. exposure of sample B at 700° F. For a given weight loss, the ratio between hydrogen increase per unit weight loss (d/c) is greater when the hydride concentration is high (2.5%). The higher d/c ratios of sample

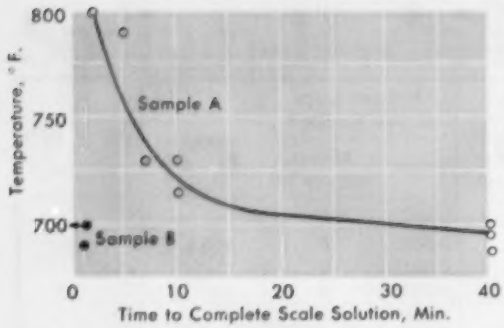


Fig. 1 – Completion of Descaling as a Function of Temperature and Scale Thickness.

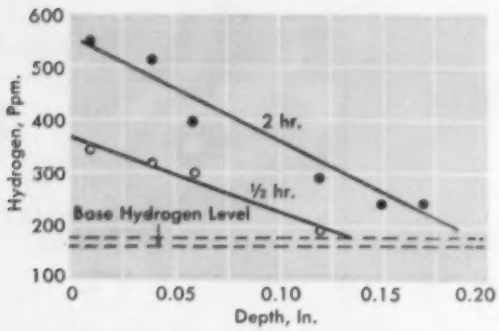


Fig. 2 – Hydrogen Diffusion in Forged Titanium Bar Exposed in 1.0% NaH Bath at 720° F.

B are related to the difference of gage between A and B. Assuming equivalent hydrogen absorption for a given weight loss, the hydrogen would be distributed through a thinner cross-section in the B material. For hydrogen analysis, all samples were cut to have equal surfaces exposed to the bath rather than equal weights.

The low d/c ratio at 800° F. for Sample A may be associated with a change in the hydrogen diffusion rate and metal-attack reaction equilibria. Detailed experiments would be required to establish an absolute relation between metal attack and hydrogen pick-up. From a practical standpoint, the data indicate that low hydride concentrations favor low hydrogen pick-up.

All the exposed coupons of sample A met the base bend test. Some sample B specimens were charged to very high hydrogen levels (600 to 1300 ppm.) and more critical bend testing was conducted. Results were as follows:

Hydrogen, Ppm.	Bend Value
110 to 400	¾ T
400 to 900	1 T
900 to 1300	1¾ T

The 70,000-psi. minimum yield grades have a bend specification of approximately 2T. With simple bending this particular heat would have passed specifications with hydrogen content as high as 1300 ppm.

The bend end-point of high-hydrogen samples is an important clue. As the bend radius is decreased, low-hydrogen (100 to 200 ppm.) material will fail in a ductile manner. Surface checking takes place before the entire cross section fails. When hydrogen is high, the sample will pass or fail in an entirely brittle fashion. Partial fracture rarely occurs.

Prolonged exposure in a hydride bath would appear to improve the bend characteristics to some extent. It removes small notches by making the metal surface smoother, and may dissolve some thin, high-oxygen surface layers formed during fabrication. The apparent improvement in ductility is obtained at the price of increased hydrogen content. The thin, high-oxygen surface layers can be removed by acid pickling.

Hydrogen Diffusion

Several runs were made using 3-in. commercially pure bar stock forged in the laboratory to ¾ in. round. This was done to provide a large cross section to study hydrogen diffusion by lathe-cutting 0.010-in. increments and analyzing samples taken at various depths from the surface.

Figure 2 illustrates the diffusion gradient of hydrogen in the test bars for ½-hr. and 2-hr. exposure times in a hydride bath at 720° F. containing 1% sodium hydride. At constant depths of penetration, the absorption is not linear with respect to time. It is believed that the hydrogen build-up as metal attack proceeds is affecting the surface chemical reactions that are taking place. Presumably, free hydrogen is not present in the bath, and chemical reaction must account for the hydrogen absorbed.

Microstructural studies of these rod sections show heavy concentration of titanium hydride "needles" near the surface exposed to the bath, with progressive diminishing of hydride phase toward the center of the section. The gradients observed in the bar stock indicate that the gradient observed in sheet would be related to gage. This in turn would affect sheet properties.

To minimize hydrogen absorption, the descaling cycles should always be held to the shortest time required for scale removal.

Editor's Note – A modified bath that may reduce hydrogen absorption is described in a supplementary note on p. 119.

Book Review...

Copper – The Industrial Picture and Supply Problem

*Reviewed by R. G. THOMPSON**

COPPER – THE SCIENCE AND TECHNOLOGY OF THE METAL, ITS ALLOYS AND COMPOUNDS. Edited by Allison Butts. Reinhold Publishing Corp., New York. 936 p. $20.

This comprehensive treatise edited by the head of the department of metallurgical engineering at Lehigh University, provides a reference work on copper, both as a chemical element and as an industrial metal. It is not a theoretical text, but rather a compilation of facts and data. It covers mining and mineralogy, the smelting and refining, fabrication and properties of copper and its alloys, both in cast and wrought forms, and their applications. In addition the reader will find information pertaining to the physical chemistry of copper, phase diagrams, isotopes, simple inorganic compounds of copper, analytical chemistry, copper in organic chemistry and in biology, as well as various examples of how this element affects our every-day life.

No one individual could write so comprehensive a survey, and Dr. Butts enlisted the support of 43 leading authorities in this country and abroad to write the various chapters. Likewise, no one reviewer can report adequately on all the important phases covered, and I therefore attempted to evaluate the text by seeking answers to specific questions based on my own experience in the fabrication and use of copper and its alloys.

During the war years, the availability and supply of copper were a most critical matter, and I was curious to see what could be learned regarding this topic. Lawrence Addicks in Chapter I shows graphically the annual world output of copper from 1810 to 1950. Prior to 1900 the output was less than 500,000 short tons, in 1910 approximately 900,000, in 1930 1,700,000, and in 1950 approximately 2,500,000 tons. Quoting Mr. Addicks, "If the total continues along this curve it is hard to see where the copper is going to be found." Mr. Addicks also points out that today approximately 50% of the copper produced goes to wire mills, 45% to brass mills, and 5% to miscellaneous uses. D. K. Crampton in a later chapter points out that the usage of copper is distributed 55% to electrical applications, 15% to construction and builders' supplies, 12% to automotive, 18% miscellaneous. With this heavy use going to electrical applications, it is interesting to compare the output of copper to the kilowatts of electrical power generated in the U.S.:

1920	56.56 billion kw-hr.
1930	114.64
1950	388.67
1955	602.00†
1960	903.00†
1964	1173.40†

With this tremendous increase in the use of electrical energy forecast by the last three figures, certainly Mr. Addicks' statement "it is hard to see where the copper is going to be found" deserves a lot of thought.

With constant improvements being made in electrical insulating films, designers of equipment can build more compact motors and generators with closer spacing between the copper conductors in a coil. The use of thinner insulating films demands the production of wire and bars with exceptional freedom from surface defects such as slivers and scabs which could damage the insulating films. Mr. Poland indicates in his chapter on "Hot Working of Copper and Copper Alloys" that a problem exists in the produc-

*Engineering Manager, Materials & Processes Laboratory, Major Appliance Laboratories, General Electric Co., Louisville, Ky.

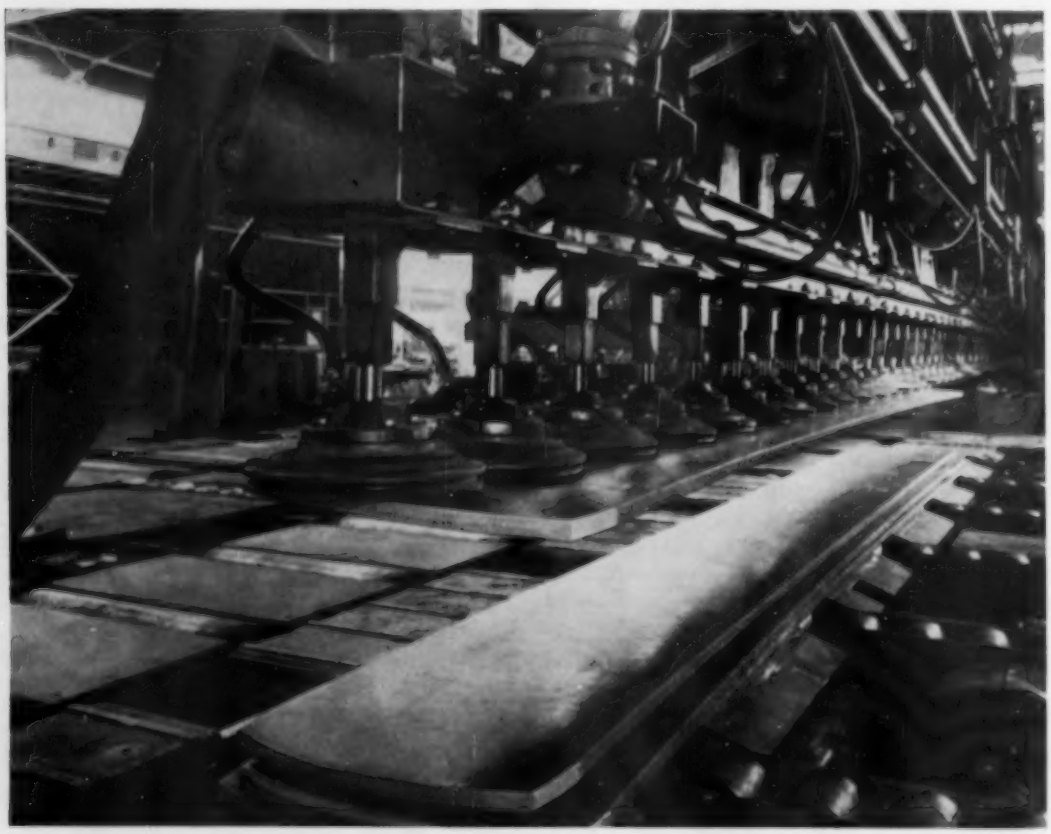
†Forecasts by General Electric Co., Market Research Section.

tion of such high-quality surfaces, but does not show what the current practices are to minimize surface defects. Nor does Mr. Toussaint in his chapter on cold working. True, this may be a very special problem, but large tonnages of copper are used where surface defects are critical, and I am sure that the problem will become more critical as better insulating films are developed which will allow even closer spacing between turns in a coil.

This comment is not intended to imply that the subject of hot and cold working of copper and copper alloys is inadequately covered. Methods of working are concisely reported, as are types of mill equipment used, ability of the metal to be hot and cold worked, effect of impurities on workability, and resulting physical and mechanical characteristics.

For those who have been associated with the manufacture of enameled magnet wire, the problem of annealing the copper simultaneously during the baking cycle for the insulating enamel is not new. Mr. Smart in a chapter on "The Effects of Impurities in Copper" presents some interesting data on the effect of impurities on conductivity and annealing properties. It is not only the basic impurity content, but also the form in which the impurity exists as a result of oxidation reactions and thermal treatment that determines the effect on such properties as electrical conductivity, annealing characteristics, grain growth, and variations resulting from hot and cold working.

One could cite many examples from all the chapters of the wealth of information contained in Dr. Butts's text. It is not a book to be read from cover to cover just to be better informed, but rather a reference text where one can seek specific information. Its broad scope, the excellent subject index and the many references listed with each chapter make this a worth-while addition to the technical library.



Rolling of Copper Bars in Scovill Mfg. Co.'s Continuous Strip Mill. A vacuum-cup handling system aids in eliminating dents, pits, gouges and other surface defects

Correspondence . . .

Hydride Modified to Reduce Hydrogen Absorption

NIAGARA FALLS, N. Y.

A method that shows promise for overcoming the problem of hydrogen absorption by titanium in sodium hydride descaling has just been found. By modifying the composition of the standard bath used by Barth and Feild (p. 114), absorption of hydrogen and solution of titanium metal are significantly decreased. The modified bath descales titanium, stainless steel and alloy steel as well as the unmodified bath.

Titanium dioxide is added to hydride to form a saturated solution. The physical form of the oxide used is important and it must be added carefully because of the explosion hazard of the hydrogen evolved.

A complete report on the titanium dioxide-modified hydride bath for descaling titanium will be published in the near future.

Q. de L. WHEATLEY
Electrochemical Dept.
E. I. du Pont de Nemours & Co., Inc.

Emancipation From Slavery to Noughts

DERBY, ENGLAND

American metallurgists and engineers enslave scientists and technicians to the reading of noughts, zeros or nils.

A member of A.S.M. for nearly 30 years, I now venture to suggest that we have done nought about noughts during all that time, and I wish to ask whether future generations must be slaves to our noughts.

Writing in column 1 of the table below, for example, some tensile strength figures, as given on p. 108 of *Metal Progress* for February 1955, we use 56 typist's strokes. The same significant figures are typed in each of the six columns. Which do you read accurately with the most ease, at the greatest distance or at the highest speed?

It is easier to read the same significant figures in column 4 (that is, knocking off 000) and that needs only 30 typist's strokes instead of 56.

Seeking emancipation from our ridiculous slavery to noughts, could we not agree to print chemical analyses of metals as °/ooo instead of as %?

Expressed as parts per ten thousand, instead of the present parts per hundred, our typists and printers may save one third to two thirds of their strokes and speed of their readers' effort.

It would be in keeping with good modern trends if we streamlined our recording of tensile test and chemical analysis figures. Why not do so?

T. HENRY TURNER
Superintendent, Metallurgy Div.
British Transport Commission

1	2	3	4	5	6
As Now Printed	× 10	× 100	× 1000	× 10,000	× 100,000
108,000	10,800	1,080	108	10.8	1.08
134,000	13,400	1,340	134	13.4	1.34
155,600	15,500	1,550	155	15.5	1.55
112,000	11,200	1,120	112	11.2	1.12
165,500	16,550	1,655	165.5	16.55	1.655
156,400	15,640	1,564	156.4	15.64	1.564
137,600	13,760	1,376	137.6	13.76	1.376
135,000	13,500	1,350	135	13.5	1.35
56 strokes	48	40	30	35	35

ELECTROMET

TRADE-MARK

ALLOYS FOR THE STEEL, IRON, AND NON-FERROUS INDUSTRIES

BORON ALLOYS

Ferroboron Min. 10.00% Boron Grade	Aluminum ...max. 0.50% Carbon .....max. 1.50%	Increases hardenability of steel; also, for additions to malleable iron and aluminum alloys.
Min. 17.50% Boron Grade	Aluminum ...max. 0.50% Carbon .....max. 0.50%	
Manganese-Boron	Boron .....min. 17.50% Manganese ..approx. 75% Carbon .....max. 3% Iron .....max. 5%	Used to cleanse and deoxidize non-ferrous alloys.

CALCIUM ALLOYS

Calcium-Silicon	Calcium .....30 to 33% Silicon .....60 to 65% Iron .....1.50 to 3%	Deoxidizer for high-quality steel. Also used in high-tensile gray irons.
Calcium-Manganese-Silicon	Calcium .....16 to 20% Manganese ...14 to 18% Silicon .....53 to 59%	A complex deoxidizer used widely in production of steel castings.
Calcium Metal Regular Grade	Calcium .....98% Balance largely Calcium Chloride	Deoxidizer and degasifier for steel and non-ferrous metals.
Distilled Grade	Calcium..approx. 99.50% Balance largely Magnesium	For special applications requiring calcium of very high purity.

CHROMIUM ALLOYS

"Simplex" Low-Carbon Ferrochrome No. 1	Chromium ....63 to 66% Silicon .....5 to 7% Carbon ....max. 0.010% or 0.025%	Suitable for all grades of steel containing chromium, and especially designed for stainless and high-alloy steels where substantial quantities of chromium are required. The silicon in the No. 1 alloy provides means of reducing metal oxides back from the slag and also increases the rate of solubility of the ferrochrome, thus providing a saving in furnace time. For those applications where high silicon is undesirable, "Simplex" No. 2 has been designed to provide an alloy which gives the desired characteristics of very close carbon control together with high chromium recoveries.
2% Nitrogen-Bearing Grade	Chromium ....62 to 65% Silicon .....5 to 7% Nitrogen .....2 to 2.5% Carbon ....max. 0.025%	
5% Nitrogen-Bearing Grade	Chromium ....60 to 63% Silicon .....5 to 7% Nitrogen .....5 to 6% Carbon ....max. 0.025%	
"Simplex" Low-Carbon Ferrochrome No. 2	Chromium ....63 to 66% Silicon .....max. 1.50% Carbon .....max. 0.03%	
2% Nitrogen-Bearing Grade	Chromium ....62 to 65% Silicon .....max. 1.50% Nitrogen .....2 to 2.5% Carbon .....max. 0.03%	
5% Nitrogen-Bearing Grade	Chromium ....60 to 63% Silicon .....max. 1.50% Nitrogen .....5 to 6% Carbon .....max. 0.03%	
Low-Carbon Ferrochrome (Other Grades)	Chromium ...67 to 71% Silicon ...0.30 to 1.00% Carbon (10 Grades) max. 0.02 to max. 2.00%	Production of stainless steels and high-temperature alloys requiring low carbon content.
High-Carbon Ferrochrome 2.25 to 3.00% Carbon Grade	Chromium ....66 to 70% Silicon .....max. 2% Sulphur .....max. 0.03%	Suitable for the production of all grades of alloy steel, including the high alloys, such as stainless steel.
Max. 4.50, 5.00, or 6.00% Carbon Grade	Chromium ....67 to 70% Silicon .....1 to 2%	
Max. 7.00% Carbon Grade	Chromium ....66 to 69% Silicon .....1 to 3%	
Min. 7.00% Carbon Grade	Chromium ....65 to 68% Silicon .....1 to 3%	
57 to 64% Chromium Grade	Carbon .....3.5 to 5% Silicon .....2 to 4.5%	
Nitrogen-Bearing Low-Carbon Ferrochrome	Chromium ....65 to 70% Silicon ...0.30 to 1.00% Carbon .... max. 0.10% Nitrogen ..0.75 to 2.00%	For additions of nitrogen to improve properties of high-chromium steels.
"SM" Ferrochrome	Chromium ....60 to 65% Silicon .....4 to 6% Carbon .....4 to 6% Manganese ....4 to 6%	A high-solubility chromium addition for steel or iron in either furnace or ladle.

CHROMIUM ALLOYS cont.

Exothermic Ferrochrome 5	Chromium ..approx. 50% Carbon ....approx. 2.5%	These improved exothermic ladle alloys have high solubility, low carbon pickup, and high ignition temperature.
Exothermic Ferrochrome 8	Chromium ..approx. 48% Carbon .....approx. 4%	
Exothermic Silicon-Chrome	Chromium ..approx. 46% Silicon .....approx. 23% Carbon .....max. 1.00%	
Foundry Ferrochrome High-Carbon Grade	Chromium ....62 to 66% Silicon .....7 to 10% Carbon .....5 to 7%	A high-solubility ferrochrome, developed especially for ladle additions of chromium to cast iron.
Low-Carbon Grade	Chromium ....50 to 54% Silicon .....28 to 32% Carbon .....max. 1.25%	
Chromium Metal High-Carbon Grade	Chromium ....87 to 90% Carbon .....9 to 11% Iron .....max. 1.25%	For production of a wide variety of chromium-bearing alloys, including electrical resistance alloys and high-temperature alloys.
Electrolytic Grades Laboratory Grade	Chromium ..min. 99.20% Iron .....max. 0.03%	
Commercial Grade	Chromium ..min. 99.00% Iron .....max. 0.30%	
"EM" Ferrochrome-Silicon	Chromium ....39 to 41% Silicon .....42 to 46% Carbon .....max. 0.05%	Used essentially in the production of stainless steel.
"EM" Ferrosilicon-Chrome	Chromium ....50 to 54% Silicon .....28 to 32% Carbon .....max. 1.25%	For adding chromium and silicon to steels containing up to 1 or 2 per cent chromium.
"EM" Chromium Briquets (Hexagonal Shape)	Chromium .....2 lb. Total Weight .....3⅜ lb.	For adding chromium to cast iron in the cupola.

COLUMBIUM ALLOYS

Ferrocolumbium	Columbium ...50 to 60% Silicon .....max. 8% Carbon .....max. 0.40%	Stabilizer in austenitic chromium-nickel stainless steels. Also constituent of high-temperature alloys.
Ferrotantalum-Columbium	Columbium ..approx. 40% Tantalum ...approx. 20% Cb + Ta .....min. 60% Carbon .....max. 0.30% Iron .....approx. 25%	Used to supplement ferrocolumbium in chromium-nickel stainless steels and high-temperature alloys.

MANGANESE ALLOYS

Standard Ferromanganese Regular Grade	Manganese ...74 to 76% Carbon .....approx. 7% Silicon .....max. 1%	Most common means of adding manganese to steel for both alloying and deoxidizing purposes. Also for counteracting sulphur in steel and cast iron.
Low-Phosphorus Grade	Manganese ...78 to 80% Carbon .....max. 7% Silicon .....max. 2% Phosphorus ..max. 0.10%	
Low-Carbon Ferromanganese Low-Phosphorus Grade	Manganese ....min. 90% Carbon .....max. 0.07% Phosphorus ..max. 0.06%	Used for making additions of manganese to steels of low-carbon specification, particularly stainless steels.
Regular Grades	Manganese ...85 to 90% Carbon ..max. 0.07, 0.10, 0.15, 0.30 or 0.50%	
Regular Grade (High-Silicon)	Manganese ...80 to 85% Carbon .....max. 0.75% Silicon .....5 to 7%	
"Mansiloy" Alloy	Manganese ...60 to 63% Silicon .....28 to 31% Carbon .....max. 0.07% Phosphorus ..max. 0.05%	Used essentially in the production of stainless steels.
Silicomanganese Max. 1.50% Carbon Grade	Manganese ...65 to 68% Silicon .....18 to 20%	A versatile alloy useful as a furnace block and deoxidizer, and also for an alloy addition to steel in the ladle or furnace.
Max. 2.00% Carbon Grade	Manganese ...65 to 68% Silicon ....15 to 17.50%	
Max. 3.00% Carbon Grade	Manganese ...65 to 68% Silicon ....12 to 14.50%	

All of the alloys and metals listed are produced in the usual lump, crushed, or ground sizes, except where other special forms are indicated.

MANGANESE ALLOYS cont.

Medium-Carbon Ferromanganese	Manganese ...80 to 85% Carbon ...1.25 to 1.50% Silicon max. 1.00 or 1.50%	An intermediate carbon ferromanganese alloy for addition to steel.
Low-Iron Ferromanganese	Manganese ...85 to 90% Carbon ...approx. 7.00% Silicon .....max. 3% Iron .....max. 2%	For high manganese additions to certain non-ferrous alloys, particularly aluminum.
Manganese Metal Electrolytic Grade	Manganese . min. 99.90%	Used wherever manganese of high purity is required in the production of stainless steel and non-ferrous alloys.
Nitrogen-Bearing Grade	Manganese ..approx. 93% Nitrogen ....approx. 6%	
"EM" Silico-manganese Briquets (Square Shape)	Manganese ..... 2 lb. Silicon .....½ lb. Total Weight .....3½ lb.	For adding manganese (with silicon) to cast iron in the cupola.
"EM" Ferro-manganese Briquets (Oblong Shape)	Manganese .....2 lb. Total Weight .....3 lb.	For adding manganese (without silicon) to cast iron in the cupola.

SILICON ALLOYS

50% Ferrosilicon Regular Grade	Silicon .....47 to 51%	Deoxidizer for most grades of killed or semi-killed steel. The blocking grade is specially sized for maximum efficiency.
Blocking Grade	Silicon .....47 to 51%	
Boron-Bearing Grade	Silicon .....47 to 51% Boron ....0.04 to 0.05% Or higher if desired	
Low-Aluminum Grade	Silicon .....47 to 51% Aluminum ...max. 0.40% or 0.10%	
65% Ferrosilicon Regular Grade	Silicon .....65 to 70%	For furnace or ladle addition to steels.
Low-Impurity Grade	Silicon ..61.50 to 66.50% Aluminum ...max. 0.50% Total Impurities max. 1.00%	Commonly used for production of electrical sheet steel.
75% Ferrosilicon Regular Grade	Silicon .....73 to 78%	Deoxidizer and alloy for production of high-silicon spring and electrical sheet steel. Graphitizing inoculant for cast iron.
Low-Aluminum Grade	Silicon .....73 to 78% Aluminum ...max. 0.50%	
85% Ferrosilicon Regular Grade	Silicon .....83 to 88%	Enables melter to add higher percentages of silicon without chilling metal in ladle. Graphitizing inoculant for cast iron.
Calcium-Bearing Grade	Silicon .....83 to 88% Calcium ....min. 0.50%	
Low-Aluminum Grade	Silicon .....83 to 88% Aluminum ...max. 0.50%	
90% Ferrosilicon Regular Grade	Silicon .....92 to 95%	Permits large additions of silicon without harmful chilling effect.
Low-Aluminum Grade	Silicon .....92 to 95% Aluminum ...max. 0.50%	
Silicon Metal Regular Grade	Silicon min. 98 or 96.50% Iron..max. 0.75 or 1.50% Calcium ....max. 0.07%	Additions of silicon to non-ferrous metals, particularly aluminum and copper.
Purified Grade	Silicon ..99.70 to 99.90% Iron .....005 to .015%	For applications in non-ferrous industry requiring silicon of high purity.
Low-Calcium Grade	Silicon .....min. 98% Iron .....max. 0.75% Calcium ....max. 0.03%	For high-silicon aluminum alloys where calcium is detrimental.
Low-Aluminum Grade	Silicon .....min. 98.50% Iron .....max. 0.75% Aluminum ...max. 0.10% Calcium ....max. 0.03%	For the production of silicon-copper alloys where aluminum is detrimental.
"EM" Silicon Briquets		
Large Size (Cylindrical or Brick-Shape)	Silicon .....2 lb. Total Weight .....5 lb.	For adding silicon to cast iron in the cupola.
Small Size (Cylindrical Shape)	Silicon .....1 lb. Total Weight .....2½ lb.	

SILICON ALLOYS cont.

"SMZ" Alloy	Silicon .....60 to 65% Manganese ....5 to 7% Zirconium .....5 to 7%	Particularly strong graphitizing inoculant used in cast iron.
Magnesium-Ferrosilicon Regular Grade	Silicon .....43 to 47% Magnesium ..7.5 to 9.5%	For addition to cast iron and steel to obtain special properties.
Cerium-Bearing Grade	Cerium ...approx. 0.50%	

TITANIUM ALLOYS

Ferrotitanium	Titanium ..27 to 32%, 50 to 55%, or approx. 70% Carbon .....max. 0.10%	For stabilized stainless steels and high-temperature metals.
Silicon-Titanium	Titanium .....40 to 50% Silicon .....45 to 50% Iron .....max. 3%	For additions of titanium to steel, cast iron, or nonferrous alloys.
Manganese-Nickel-Titanium	Titanium ...approx. 48% Nickel .....approx. 31% Manganese .approx. 6%	For adding nickel and titanium to high-temperature alloys.

TUNGSTEN ALLOYS

Ferrotungsten	Conforming to A.S.T.M. Spec. A 144-50	Production of tool and die steels; also high-temperature alloys.
Tungsten Metal Powder Melting Grade	Tungsten ...min. 98.80% Total Carbon..max. 0.25%	Production of tungsten steels and cast tungsten carbide.
Calcium Tungstate	Tungstic Oxide..68 to 72%	For making tungsten chemicals and other tungsten products.
Calcium Tungstate Nuggets	Tungstic Oxide..68 to 72%	For producing tool steels and high-temperature alloys.
Ammonium Paratungstate	Tungstic Oxide.min. 88.7%	Intermediate for tungsten products.

VANADIUM ALLOYS

Aluminum-Vanadium	Vanadium ....80 to 85% Aluminum ....13 to 16% Iron .....max. 1% Silicon .....max. 1% Oxygen .....max. 0.25%	For adding aluminum and vanadium to titanium metal and alloys.
Ferrovanadium	Vanadium ....50 to 55% or 70 to 75% Carbon ..max. 0.20, 0.50, or 3.00% Silicon ..max. 1.50, 2.00, or 8%; and approx. 10%	Production of tool and engineering steels, high-strength structural steels, non-aging rimming steels, and wear-resistant irons.
Vanadium Oxide Fused	V_2O_5 .....86 to 89% Na_2O .....approx. 10% CaO .....approx. 2%	For addition of vanadium to steel and for manufacturing catalysts.
Sodium Polyvanadate (Red Cake)	V_2O_5 .....approx. 85% Na_2O .....approx. 9%	
High-Purity	V_2O_5 ....approx. 99.50%	For manufacture of vanadium compounds, including vanadium catalysts.
Ammonium Metavanadate	NH_4VO_3 .....min. 99%	

ZIRCONIUM ALLOYS

12 to 18% Zirconium Alloy	Zirconium ....12 to 15% Silicon .....39 to 43% Carbon .....max. 0.20%	A powerful deoxidizer. Also increases depth of hardening of steel.
35 to 40% Zirconium Alloy	Zirconium ....35 to 40% Silicon .....47 to 52% Carbon .....max. 0.50%	Steel deoxidizer when higher concentration of zirconium is desired.
"EM" Zirconium Briquets (Cylindrical Shape, Red Color)	Zirconium .....0.55 lb. Silicon .....1.90 lb. Total Weight .....5 lb.	For adding zirconium and silicon to cast iron in the cupola.

"Electromet," "EM," "Manalloy," "Simplex," "SM," and "SMZ," are trade-marks of Union Carbide and Carbon Corporation.

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More than 50 different alloys and metals are produced by ELECTROMET. If you need help in selecting the proper alloys, be sure to consult one of ELECTROMET'S specially trained metallurgists and engineers. Address your inquiries to one of the offices listed at right.

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Personal Mention

C. E. Hawke

Walter H. Holcroft

Three members who have made important contributions to the science of industrial heating and to its application in national defense were recent recipients of the nation's top honor for achievement in the industry, the Trinks Award. They are WALTER H. HOLCROFT, executive vice-president and technical director of Holcroft & Co., Detroit; C. E. HAWKE, vice-president of the Carborundum Co., Niagara Falls, N. Y.; and HORACE DREVER, president of Drever Co., Bethayres, Pa. The award, which was established in honor of Dr. Willibald Trinks, professor emeritus of Carnegie Institute of Technology is bestowed annually by a judges' panel of industrial heating authorities.

Mr. Holcroft was cited for his work on gas carburizing and carbonitriding furnaces, and for contributions to short-cycle malleable annealing furnaces and improvements on standard conveyer furnaces. Mr. Holcroft joined Holcroft & Co. upon graduation from the University of Michigan in chemical engineering.

Mr. Hawke was recognized as a pioneer developer of super refractories so necessary to today's high-temperature production and heat treating of metals. One application of silicon carbide refractories to retorts revolutionized the production of zinc metal; more recent work has been in relation to the manufacture of guided missiles. Mr. Hawke graduated from Battersea Polytechnical Institute, England, in mechanical engineering, and afterward joined the Carborundum Co. through its affiliate plant in Germany. In 1913 he returned to this country as manager of sales engineering at the company's Niagara Falls plant. During World War I, he was with the U. S. Army Air Service, and in 1919 was placed in charge of sales of the refractories division.

Mr. Drever was cited for his development of the continuous vertical strip annealing furnace, for originating the present-day method of bright annealing stainless steel wire and tubing, and for developing furnaces and quenching equipment for continuous heat treating of armor plate. After attending Pennsylvania State College, Mr. Drever began his professional career with the Electric Furnace Construction Co., rising to chief engineer. He was later chief engineer and a vice-president of the Gas Equipment Co., and in 1938 formed his own organization, the Drever Co. Mr. Drever is the author of the article "Surface Protection of Titanium and Stainless Steel During Heat Treatment," which appeared in *Metal Progress* in June 1955.

James L. Oberg has joined Metal & Thermit Corp., New York, as technical advisor. Mr. Oberg has been associated with the Babcock & Wilcox Co. for the past 15 years.

Horace Drever

Benjamin H. Danziger has been appointed manager of catalyst and pigment development at Climax Molybdenum Co., New York. Prior to this appointment, he held the position of chemical development engineer.

Norman K. Pettigrew recently joined the executive staff of Sargeant & Wilbur, Inc., Pawtucket, R. I., as general manager. He had been with C. I. Hayes, Providence, R. I., for 26 years in various capacities, his most recent position being sales and advertising manager with additional responsibilities in research and development. **Marshall C. Battey** has also joined the Sargeant & Wilbur organization as New England sales representative. Mr. Battey was formerly a sales engineer for C. I. Hayes.

Leon M. Petryck has joined the development and research division of the International Nickel Co., Inc., as a research metallurgist in the welding section of the Research Laboratory at Bayonne, N. J. Mr. Petryck is a graduate of Rensselaer Polytechnic Institute, holding a B. S. degree in metallurgical engineering. Prior to his present appointment, he was a welding engineer with Carrier Corp., Syracuse, N. Y., where he supervised fabrication of nickel-plated steel for the U. S. Atomic Energy Commission.

R. W. Elmenthaler has resigned as liaison engineer for Surface Combustion Corp., Toledo, Ohio, to organize an industrial technical publicity department for Hugo Wagenseil & Associates, Dayton, Ohio.

Arc welding of the Filter/Separator.

Gasoline Filter/Separator made by Bendix-Skinner Division almost entirely of Revere 90-10 Cupro-Nickel.

It has been found that minute traces of water in aviation gasoline can stop the engine when flying in low temperatures, as at high altitudes, or over the pole. The amount of water involved is so small that it would not bother an automobile carburetor. To remove it for safe flying requires a special Filter/Separator. All metal parts going into this filter were specified to be 90-10 Cupro-Nickel. One of the contractors for the U. S. Navy is the Bendix-Skinner Division of the Bendix Aviation Corporation, Royal Oak, Mich. When Bendix-Skinner obtained the order, it called in Revere's Technical Advisory Service. A complete study was made of the blueprints and specifications, in order to set up the most economical purchasing schedules. When production began, personnel from the Welding Section of the Research and Development Laboratory maintained by Revere in Rome, N. Y., went to the Bendix-Skinner plant to share their know-how with the welders, so as to be sure the welds would pass strict inspection, yet be made at competitive costs.

Cupro-Nickel, 90-10, is highly resistant to corrosion and other forms of attack. Because it contains only 10% nickel, it is more economical than the richer alloys, yet in many applications just as satisfactory. We suggest you look into it.

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Personals . . .

W. M. Parris, formerly assistant chief, light metals division, Battelle Memorial Institute, Columbus, Ohio, has joined the technical department, metallurgical division staff of Titanium Metals Corp. of America at Henderson, Nev.

William J. Murray has been transferred by Surface Combustion Corp., from the Syracuse, N. Y., office to take charge of the Ardmore (Philadelphia), Pa., office, and **William M. Dempster** has been moved from Chicago to manage the Syracuse office. A graduate of the University of Utah, Mr. Murray has been with Surface since 1937, and has managed the Syracuse heat treat office since 1941. Mr. Dempster has been with Surface since he was graduated from Purdue University in 1941. He served in the U. S. Army for four years, being discharged as a major, and has been a member of Surface Combustion's Chicago heat treat sales office since 1946.

M. D. Bellware has joined the International Nickel Co., Inc., New York, as a member of the welding group of the development and research division's technical service section, and will devote most of his time to the iron-base alloys, particularly the austenitic stainless steels. Mr. Bellware became associated with the manufacturing engineering laboratory of Westinghouse Electric Corp. in 1951 after graduating from Ohio State University with the degree of bachelor in welding engineering. From 1952 until his present appointment, he served with Kaighin and Hughes, Inc., and the Rust Engineering Co. as welding engineer on U. S. Atomic Energy Commission projects at Oak Ridge, Tenn.

Marvin L. Kaufmann recently joined Pioneer Tool Engineering, Inc., El Segundo, Calif., as assistant to the president, and is manager of two wholly owned subsidiaries, the Consolidated Casting Co. and Republic Smelting and Refining Co. Mr. Kaufmann graduated from the University of Illinois with a B. S. degree in chemical engineering. For 21 years he was associated with the U. S. Reduction Co., East Chicago, Ind., the last 13 years as vice-president in charge of operations.

Bernard Kopelman has been appointed chief engineer of the atomic energy division of Sylvania Electric Products, Inc., New York. Formerly a research chemist with Titanium Alloy Mfg. Co., Niagara Falls, N. Y., Dr. Kopelman joined Sylvania's metallurgy research laboratory in 1944 as a senior engineer. For the past three years he served as manager of technical coordination for the division. Dr. Kopelman was educated at Clark University, and has published papers in the fields of metallurgy and chemistry on subjects concerning high-temperature metals, rare metals, and atomic energy, and holds a number of patents in these fields.

Richard F. Harvey, formerly chief metallurgist of the Brown & Sharpe Mfg. Co., Providence, R. I., is a recent addition to the metallurgical staff of the Braeburn Alloy Steel Corp., Braeburn, Pa.

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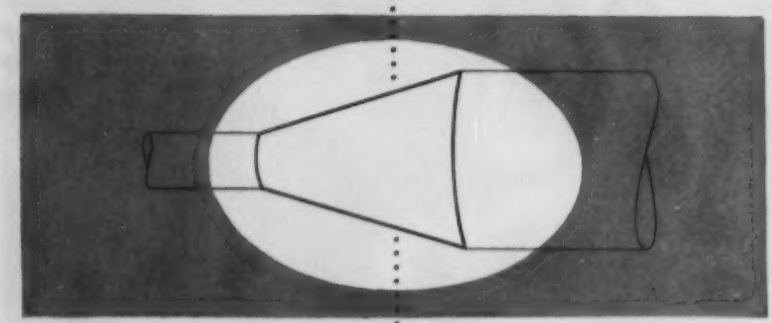

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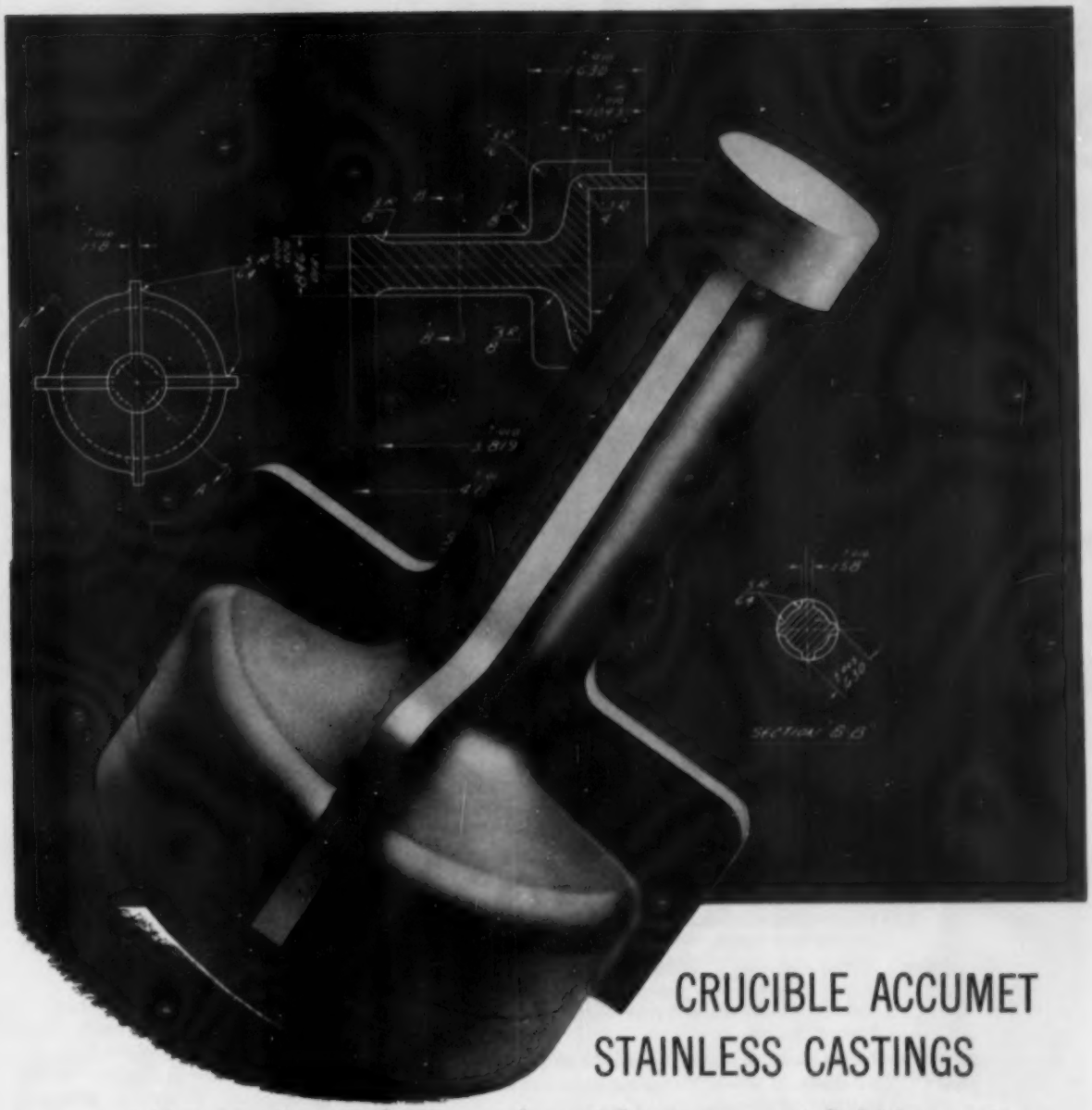

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Even intricately shaped parts, like this cream separator neck piece, can be used essentially as-cast when produced by the ACCUMET method. That's because ACCUMET casting employs hot molds with special inner linings. You get castings on which thin sections are minutely defined . . . and with exceptionally fine surface finish. *Costly finishing operations are practically eliminated.*

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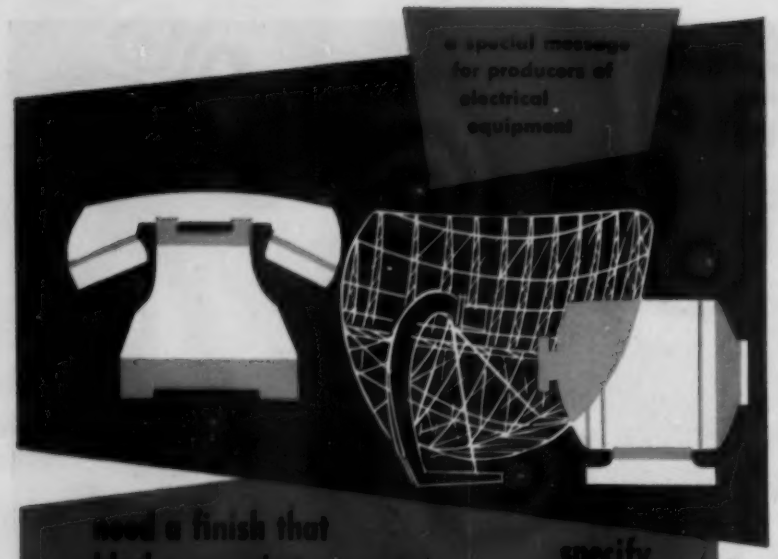

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Personals . . .

James R. Hinman has been appointed assistant sales manager of aluminum products for the Dallas (Chicago) Div. of Revere Copper and Brass, Inc. Mr. Hinman, a graduate of Worcester Polytechnic Institute, was technical advisor of the New Bedford (Mass.) Div. and has been with the company since 1941.

F. Price Norris, Jr. was recently appointed director of sales, stainless and specialty steels, for Allegheny Ludlum Steel Corp., Pittsburgh. **Royden C. Presley**, formerly manager of the Birmingham, Ala., branch of Allegheny Ludlum, has been named district manager at Buffalo, N. Y. Before going to Birmingham, Mr. Presley had been district manager at Toledo, Ohio, and had worked in the Chicago, Minneapolis, and Pittsburgh sales offices.

Harold A. Kahler has been appointed assistant to the vice-president of the Promat Div., Poor & Co., Waukegan, Ill. Mr. Kahler transferred to the home office after serving as Promat's eastern representative since 1953. Prior to this association, he held positions in the metallurgical and chemical departments of Kaiser-Frazer Corp. and Ford Motor Co., in Detroit.

Oliver H. Cook is employed as metallurgist at Casting Engineers, Inc., Chicago.

Carl A. Meyers, Jr. has resigned as engineer at Sylvania Electric Products, Inc., New York, to accept a position as engineer in the atomic power division of Westinghouse Electric Corp., Pittsburgh.

D. G. Schaffert, past chairman of Warren Chapter and for 15 years associated with Copperweld Steel Co. in that city, is now assistant to the works manager at Northeastern Steel Corp., Bridgeport, Conn. For the past eight years, Mr. Schaffert was assistant melt shop superintendent at Copperweld.

Robert P. Jensen was recently transfered from Detroit to Baltimore, Md., as branch manager for Kaiser Aluminum & Chemical Sales, Inc. Mr. Jensen graduated from Iowa State College as a mechanical engineer in 1947.

Wheeled "pig" and "crawler" used for x-raying pipeline welds. The "pig," a portable x-ray unit, is moved through the line by a self-propelled tractor or "crawler." Unit stops automatically at welds and exposes the film strip wrapped around the outside of the pipe.

Roll of processed film is checked by Clarence K. Miller (left) and Thurston E. Parker. Rugged Du Pont 506 stands up to rough handling, grease and grime through repeated inspection.

Industrial X-ray, Inc., is used to working under rugged conditions like this . . . depends on Du Pont X-ray Film for its stability to temperature change and superior resistance to fogging and abrasion.

"We're sold on the high contrast and sharp definition of Du Pont X-ray Film"

— says C. E. Boucher, Vice President and General Manager, Industrial X-ray, Inc., Seattle, Wash.

"We x-ray up to 250,000 feet of pipeline welds in a single month," says Mr. Boucher, "and in quality-control work we've got to have a film that shows up cracks, slag, porosity and other defects clearly . . . in sharp detail. That's why we use Du Pont Type 506 Industrial X-ray Film."

Mr. Boucher's company, Industrial X-ray, Inc., is the first to develop a self-propelled unit to x-ray welds from the *inside* of pipelines and was one of the first users of industrial x-ray film in rolls.

"We work under some pretty rugged conditions," Mr. Boucher goes on to say. "In the Southwest, for example, film is a target for sand, dust and terrific heat. It's here that the strong resistance of Du Pont 506 to abrasion and pitting by foreign objects really pays off. Another big advantage of Du Pont Film is its resistance to fogging under adverse storage conditions. And the quality of service we've always received from Du Pont Technical Representatives has been a big help, too."

Industrial radiographers throughout the country are finding out firsthand about the superior quality of Du Pont X-ray Films. You can, too! For samples to test in your plant . . . or for help with an x-ray problem . . . call or write your Du Pont Technical Representative or your local Du Pont District Office listed in the column at the right.

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Personals . . .

Donald J. McPherson has been promoted to assistant manager of the metals research department at Armour Research Foundation of Illinois Institute of Technology, Chicago. Formerly supervisor of the department's nonferrous metallurgy section, Dr. McPherson joined the Foundation as a research metallurgist in 1950. He was promoted to supervisor of the physical metallurgy section in 1952, and to supervisor of nonferrous metals in 1954. Dr. McPherson received B. S., M. S., and Ph. D. degrees in metallurgy, all from Ohio State University, and has written many papers on titanium.

Fred J. Walls, in charge of the Detroit technical field section of International Nickel Co., delivered the Charles Edgar Hoyt Memorial Lecture at the annual meeting of the American Foundrymen's Society, held in Houston, Tex., in May. A past president of A. F. S., Mr. Walls was selected as chief convention speaker because of his long-standing interest in improving the quality level of foundry education and his constant encouragement of young men to enter the metal castings industry. He has served as chairman or member of numerous committees of the Gray Iron and Education Divisions of A. F. S., and has contributed frequently to meetings of the foundry, engineering and metallurgical societies. Mr. Walls received his technical education at the University of Michigan, where he specialized in metallurgy, and has been associated with International Nickel since 1934.

Robert F. Thomson, head of the metallurgy department of General Motors Research Laboratories Division was awarded the John A. Penton Gold Medal by the American Foundrymen's Society at the annual meeting in May, for "outstanding contributions to the society and the industry in foundry research, particularly in the field of light metals". A graduate of the University of Michigan, where he formerly taught metal processing in the College of Engineering, Dr. Thomson joined General Motors Research Laboratories in 1950 as assistant head of the metallurgy department, and was promoted to head of the department in 1952. He is author of a number of technical publications on the subjects of magnesium and steel heat treating, corrosion testing and automotive component performance, and has been closely associated with the development of improved gating systems for metal castings. He organized and served for five years as chairman of the A. F. S. research committee on this subject. Dr. Thomson is a past chairman of the Detroit Chapter.

Ernest C. Kron, formerly steel metallurgist for the Doehler-Jarvis Div. of National Lead Co., has been promoted to division metallurgist. A graduate of the University of Minnesota as a metallurgical engineer in 1930, Mr. Kron worked for Bethlehem Steel Corp. and Republic Steel Corp. prior to affiliating with Battelle Memorial Institute, Columbus, Ohio, in research pertaining to the development of ferrous and nonferrous alloys, melting and casting problems. He left Battelle 11 years later as assistant supervisor in charge of the research foundry operations, and joined Doehler-Jarvis in 1947.

B. A. Daley, previously chief metallurgist for 15 years, has been promoted to chief engineer of the defense division of Servel, Inc., Evansville, Ind. A graduate of the University of Michigan, Mr. Daley joined Servel in 1936 as a metallurgist.

Efficiency in Cutting-off is Important

Practically all machining operations start with pieces cut-off from bars or billets. Hence, inefficiency, or lack of capacity, in the cut-off department can hold up or stagnate the entire plant.

A. Are all-ball-bearing and provide a quick return; therefore they run FASTER than others on the same work.

B. Can apply as much as 1200 pounds feed pressure—two to ten times as much as other hack saws and band saws.

C. Are fully automatic, requiring no more operator attention than an automatic screw machine; and set-up for any bar size and cut-off length is extremely simple.

D. Use a non-breakable high speed hack-saw blade — the type of saw blade that produces the greatest number of square inches of metal cut per dollar of blade cost—two to ten times (or more) as much as any band saw.

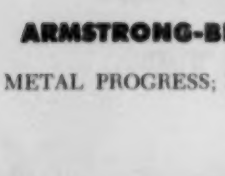
E. Because of their exceptional sturdiness, ball bearing reciprocating frame, ability to tension the blade "truly taut", their accuracy is dependable.

If you are not using modern, improved MARVEL NO. 6A and 9A production hack saws, call the local MARVEL Field Engineer and get his production and cost estimates on your work—to compare with your experience records.

THE MARVEL NO. 6A AND 9A HEAVY DUTY HACK SAWING MACHINES

Formula for Accuracy in Metal Sawing
ACCURACY = (Length, Straightness, Squareness)
Straightness, Squareness = (Blade Rigidity, Blade Tautness)
MARVEL

The composite MARVEL High-Speed-Edge Hack Saw Blade—cuts **any** machinable material efficiently. There is no time lost changing blades for different types of steel; no time lost replacing shattered blades, because MARVEL High-Speed-Edge Hack Saw Blades are positively **unbreakable.** These superior blades have the finest high speed steel cutting edge welded to a strong alloy steel body. They will stand-up under the highest speeds and heaviest feeds attainable on any make hack saw. Can be safely tensioned tauter than any other blade—cut-off not only straight but also square and with less stock loss.



Write for catalog C-55—showing and describing eleven different series of Metal-Cutting Sawing Machines and MARVEL High-Speed-Edge Hack Saw Blades and Hole Saws.

MARVEL SAWS

ARMSTRONG-BLUM MFG. CO. 5700 West Bloomingdale Avenue • Chicago 39, U.S.A.

MIDVALE *DRUM* SHAFT FORGED TO *BEAT* FATIGUE

Forge it uniformly . . . finish it to extremely close tolerances . . . and deliver it fast—they were the requirements on this large alloy steel drum shaft for a mine overseas. In record time Midvale poured the ingot, shaped the shaft in its huge presses and had it finished to an overall length of 40 feet 6 inches, diameter of 38 inches with a bore of 7 inches.

This type of service has been routine to the men of Midvale for more than a half a century. They have made a specialty of supplying the mining industry with large forgings and castings of all types. Midvale quality is carefully guarded from the time the ingot is poured until the finished piece is loaded for shipment. Tests and supervised inspections are made in every step of production. Final tests—X-ray, sonic and others as specified—assure sound forgings and stainless steel castings for outstanding performance in the most severe service.

Next time you need shafts, rolls, roll shells, gear rings or high alloy castings get in touch with Midvale. You can be certain of satisfactory service and products.

THE MIDVALE COMPANY- Nicetown, Philadelphia 40, Pa.

Offices: New York, Chicago, Pittsburgh, Washington, Cleveland, San Francisco

MIDVALE

FORGINGS, ROLLS, RINGS, CORROSION AND HEAT RESISTING CASTINGS

ACCO products

Wilson "Rockwell"* Hardness Testers

EASY TO USE
as a scale

SENSITIVE & ACCURATE
as a precision balance

DURABLE
as a machine tool

3-JR MODEL
Invaluable for tool room use and most production testing

Fully Automatic

Semi-Automatic

Superficial

Tukon Micro and Macro Hardness Testers

• WILSON "Rockwell" Hardness Testers were the first to combine in one high grade instrument the precision and sensitivity demanded in the metallurgical laboratory, the accuracy required in the tool room *plus* the ease of operation and durability for daily use on the production line.

Now the world's standard of accurate hardness tests since 1921, WILSON "Rockwell" Hardness Testers have developed to keep pace with the ever-expanding requirements of industry. Their testing scope and capacity has increased until their use in steel mills, non-ferrous mills and metal fabricating plants is universal.

A staff of WILSON hardness-testing experts is conveniently located to check your needs with you—recommend just the size and model best suited to the job. Why not call or write today?

*Trade mark registered

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ACCO **Wilson Mechanical Instrument Division**
AMERICAN CHAIN & CABLE

230-F Park Avenue, New York 17, N. Y.

for Better Value

Personals . . .

Emo D. Porro has been appointed engineering assistant to the director of Stanford Research Institute, Stanford, Calif. Mr. Porro will maintain technical liaison between the research divisions and S.R.I.'s other offices and laboratories in Los Angeles, Phoenix, Washington, D.C., Portland, Ore., and Honolulu. A member of the staff since 1948, he has held several positions of responsibility, including manager of the chemical and metallurgical engineering section.

Edward W. Sparkes has been appointed manager of the Syracuse, N. Y., branch of Crucible Steel Co. of America. Mr. Sparkes, who was made acting branch manager at Syracuse last October, has been employed at Crucible since 1935, securing a leave of absence in 1942 to serve four years in the U. S. Army. Upon his discharge, he joined the sales force at Crucible's Syracuse branch. In 1947 he was appointed sales service engineer, the position he held until his new appointment last fall.

Raymond F. Parker, formerly a sales engineer for the Carboloy Dept. of General Electric Co., Detroit, has been appointed manager of carbide component sales. Mr. Parker, who joined Carboloy ten years ago, was associated during World War II with the U. S. Atomic Energy Commission as a metallurgist on the Manhattan Project. Prior to that he was a metallurgist in the research laboratory of Aluminum Co. of America, New Kensington, Pa. He obtained his degree in metallurgical engineering from Purdue University in 1942.

Edward S. Smith was recently appointed assistant melting superintendent of the electric furnace department of Universal-Cyclops Steel Corp., Bridgeville, Pa. A graduate of Virginia Polytechnic Institute, Mr. Smith has served in various metallurgical capacities since joining the company four years ago. **Philip E. Schneider**, a metallurgical graduate of Drexel Institute, who was formerly associated with the Rustless Div. of Armco Steel Corp., has joined the company as development metallurgist.

Delivery when promised . . . dependability in every piece . . . and economically produced in stainless steel

on Carlson Order No. 17656

Not every shipment is as diversified as GOC 17656 but it illustrates the typical all-around service in stainless steel available from G. O. Carlson, Inc.

There are plates, heads, rings, circles, flanges, bars and rounds—all stainless steel to chemical industry standards—all made to match the specifications on the customer's blueprint. It took special equipment to make up this order—equipment designed and built by Carlson engineers who work *exclusively* in stainless.

This equipment in the hands of Carlson specialists *lowers* costs. You pay no freight on material you can't use and you save man-hours in easier fit-up, because the material is ready for fabrication when you get it.

When you order your stainless steel from G. O. Carlson, Inc. you can be sure of three things: (1) it is economically produced from the highest quality material; (2) it is cut to your specifications; (3) it is shipped on time. Write *right now* for complete information.

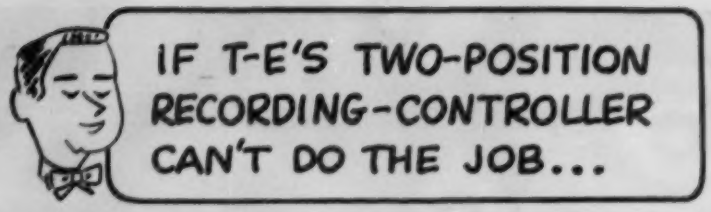
Stainless Steels Exclusively

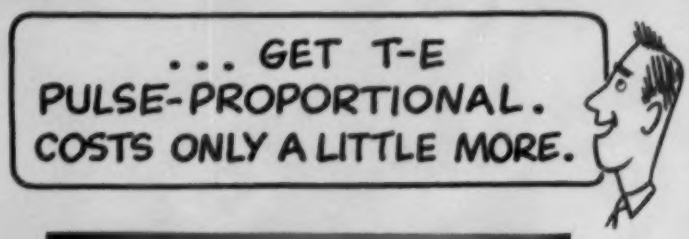
G. O. CARLSON, INC.

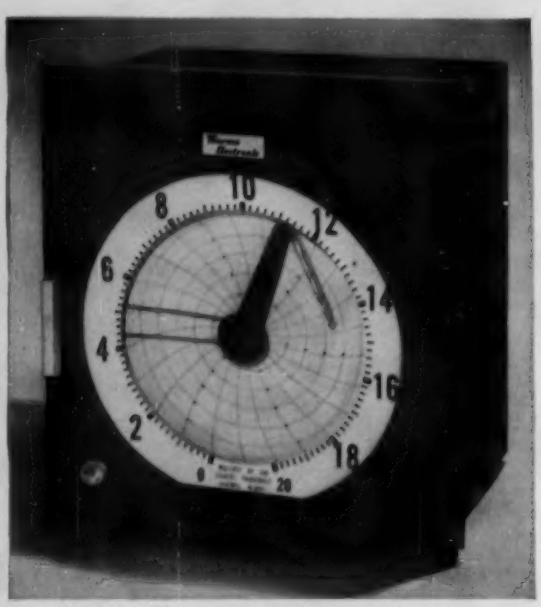
THORNDALE, PENNSYLVANIA

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

District Sales Offices in Principal Cities







Thermo Electronic recording-controllers are relatively inexpensive instruments for recording and controlling temperature of electrically heated, fuel fired, or steam heated equipment. You can use them with two-position valves (electric or electric-pilot pneumatic types), contactors, or heavy duty relays. They will operate with thermocouples or resistance bulbs.

The pulse-proportional controller changes heat input according to the magnitude of temperature change. Its proportion band is continuously adjustable from 0% to 20% of range to match process response. Recommended for continuous and other processes having similar control characteristics, where load changes are relatively small, and where temperature changes cannot be detected quickly.

Two types of controller: potentiometer pyrometer and resistance thermometer. Both are durable, simple, accurate, sensitive, speedy, and easy-to-set. 23 scale ranges from −320° to +200°F all the way up to 0° to 3000°F. The 12" recording chart is easy-to-read.

Interested? Write for bulletin 62—H.

Pyrometers • Thermocouples • Protection Tubes • Quick-Coupling Connectors
Thermocouple and Extension Wires • Resistance Bulbs • Connector Panels

Thermo Electric Co., Inc.

SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

Personals . . .

Harold B. Emerick has been named director of technical services division of Jones & Laughlin Steel Corp., Pittsburgh, succeeding **D. T. Rogers**, who was named manager of cold finished products, a division of the sales department. Mr. Emerick joined J. & L. in 1935 as a metallurgical inspector at the Aliquippa Works and became assistant chief metallurgist in 1947. In 1951 he was named assistant to the vice-president of technology and was appointed assistant director of technical services in 1953. He was co-recipient in 1942 of the McKune Award at the National Open Hearth Conference of the American Institute of Mining and Metallurgical Engineers. In the reorganization of the technical services division, **Charles L. Kent** was appointed assistant director, sales technical services, and **George H. Enzian** was made assistant director, production technical services. Mr. Kent joined J. & L. in 1927 as a shearman in the concrete bar warehouse, and was transferred to the metallurgical department, Pittsburgh Works, in 1928. In 1946 he became a technical representative for the Corporation, and in 1953 became head of the customer service section. Mr. Enzian joined Jones & Laughlin in 1935 as a metallurgical inspector at the Pittsburgh Works. He became head of the metallurgy and testing section in the research division in 1942, and in 1953 was made manager of metallurgical research. He is a past chairman of the Pittsburgh Chapter.

Kent R. Van Horn, national past president and director of research for Aluminum Co. of America, New Kensington, Pa., recently received an honorary degree of Doctor of Science from Case Institute of Technology. Dr. Van Horn received his B.S. degree from Case in 1926, and his M.S. and Ph.D. degrees from Yale University. In 1929 he joined Alcoa as a research metallurgist at the Cleveland division, and in 1950 was transferred to New Kensington as associate director of research. He was appointed to his present position in January 1952. (A biographical appreciation of Dr. Van Horn appeared in the February 1945 issue of *Metal Progress.*)

15 times the life in Acid Mixtures

AND STILL GOING STRONG

PROBLEM:

Baskets for submerging alloy steel forgings in hot pickling acids had to be replaced every month because of severe corrosion. The baskets were continually immersed in either 15 per cent hydrochloric acid, aqua regia, 10 per cent nitric and hydrofluoric acids, or 20 per cent nitric acid. All of these acids were at about 140 deg. F.

REMEDY:

The baskets were made of one-inch round bars of HASTELLOY alloy C.

RESULT:

After 15 months' service, three shifts a day, the baskets made of HASTELLOY alloy C are still good.

HASTELLOY alloy C is the most universally corrosion-resistant alloy available today. It has high-strength and is highly resistant to all of the mineral acids. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

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"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation.

now you can own your own heat-treating plant

low in cost
high in productivity
compact in design

Hundreds of shops are enjoying the advantages of their own heat-treating department with this new Waltz Heat-Treating Furnace. It heat-treats, quenches, draws, stress-relieves, normalizes, anneals, with controlled atmospheres. You avoid costly production tie-ups caused by waiting for expensive outside services. What a money-saver right from the start...what a wise investment! Mail the coupon for complete details.

Features Include:

1. *Heating Furnace with range of 1000° to 2400° F. automatically controlled (12" wide x 10" high x 18" deep).*
2. *Tempering or Drawing Oven is recirculating type. Work is constantly bathed with evenly distributed high velocity and held to constant temperature by automatic control. Alloy steel lined with perforated shelf, has range of 250° to 1100° F. (21" wide x 10" high x 18" deep).*
3. *Furnace and Oven doors equipped with foot treadles.*
4. *Two Quench Tanks for oil and water. By means of double wall construction, oil tank is entirely surrounded by water for cooling oil, thus producing more uniform quenching.*
5. *Automatic electronic type controls*
6. *Shipped ready to install by simply connecting gas and electric power line.*

A complete line of WALTZ standard or special heat-treating furnaces, using all types of fuels are built to suit your requirements. *Write for comprehensive illustrated bulletins. Dept. W*

Waltz FURNACE COMPANY
SYMMES STREET
CINCINNATI, OHIO

Personals . . .

J. D. Dickerson has been appointed to the staff of the central operating department of Crucible Steel Co. of America with headquarters in Pittsburgh. **C. S. Walton**, former staff metallurgist, has been named to succeed Mr. Dickerson as chief metallurgist at Midland (Pa.) Works. A graduate of Lehigh University in 1931 with a B.S. degree in metallurgical engineering, Mr. Dickerson served with the Ordnance Corps, U.S. Army, during World War II. Holding the rank of colonel, he was assistant chief, Research and Intelligence Branch, Metals Section, studying the ordnance and steel industries of Germany and occupied countries. He joined Crucible in 1953 as chief metallurgist at the Midland Works, previously holding the same position at the Buffalo, N.Y., plant of Republic Steel Corp. Mr. Walton was graduated from Ohio State University with a bachelor of metallurgical engineering degree and began his engineering career with Barneby and Chenny Engineering Co., Columbus, Ohio. After two years' service with the United States Navy, he joined the engineering staff of Southern Alkali Corp., Corpus Christi, Tex., in 1946. Later the same year he was appointed to the metallurgical department of United States Steel Corp., serving in Chicago, Kearney, N.J., and Pittsburgh, successively. Mr. Walton began his association with Crucible in 1953 as a staff metallurgist assigned to the central metallurgical office in Pittsburgh. The next year he was made a staff metallurgist at the company's Midland, Pa., Works, the position he held until his present appointment.

William A. Roth was recently elected vice-president and assistant general manager of the Cleveland Pneumatic Tool Co. Mr. Roth, formerly vice-president and factory manager of McDonnell Aircraft Co., St. Louis, has been affiliated with the Cleveland company since the beginning of the year, as director of manufacturing.

Douglas V. Keller, Jr. is attending graduate school in the department of chemistry at Syracuse University.

Using the Sheffield-Cavitron Ultrasonic Machine Tool to dice germanium in the mass production of transistors. The tool itself consists of 271 pieces of Superior's 18-gage Type 304 needle tubing, cut to ⅜" lengths and silver brazed into a single tool, permitting tolerances as fine as .0005".

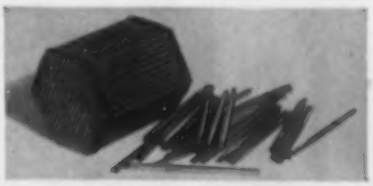
NEW ULTRASONIC MACHINE TOOL USES TUBING TO CUT HARDEST, MOST BRITTLE MATERIALS KNOWN

a new application for Superior Tubing

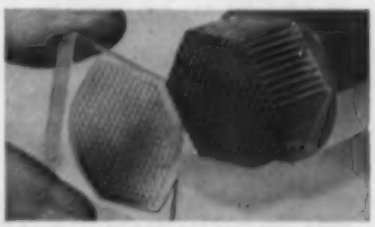
Ultrasonic vibrations do the cutting with this new machine tool, invented and developed by the Cavitron Equipment Corporation, Long Island City, N.Y. In the Cavitron process, a tool is used which has the precise shape of the cavity desired. Finely divided abrasive particles suspended in water are flowed continuously across the work. No movement or vibration is visible when the machine is switched on, although the tool tip vibrates 20,000 times a second through a stroke of .0035". The vibrating tip activates the suspended particles, and microscopic chips are gently excavated without heat, noise or vibration. The tool sinks swiftly into the work under slight pressure, forming a cut or cavity of exactly the same shape as the tip.

Tools made of Superior tubing save considerable cutting time on relatively large areas. Furthermore, the slender walls (.005" thick) minimize waste of valuable raw material. Cavitron engineers first used carbon tubing for this purpose, but in consultation with Superior engineers switched to AISI Type 304. This material has twice the life of carbon tubing, with much greater resistance to wear. Most important, it resists warping at the silver brazing temperatures needed to join the tubes together.

Your files should contain Superior Bulletin No. 40. It lists over 55 types of available material, including the stainless steels, with valuable selection and application data. Write for your free copy today. SUPERIOR TUBE COMPANY, 2008 Germantown Ave., Norristown, Pa. *On the West Coast:* Pacific Tube Co., 5710 Smithway St., Los Angeles 22, California.



Superior tubes are cut into 2" lengths and silver brazed into a 6-sided tool, which is then cut in half and two complete honeycomblike tools formed—each ⅜" deep. Similar tools are used to cut precision jewel bearings.



Closeup of tool and work shown in top picture. The Cavitron makes it possible to cut and drill intricate shapes in materials which, because of their frangibility or sensitivity to sudden temperature changes, would be impossible to work on a production basis.

All analyses available in .010" to ¼" OD; certain analyses in light walls up to 2½" OD

Superior Tube
The big name in small tubing

FOR FINE WIRE PRODUCTS . . .

Almet Stainless Steels

MEET MORE REQUIREMENTS THAN OTHER ENGINEERING MATERIALS

Does your Fine Wire application call for resistance to heat? . . . to corrosion? Does it require good fatigue properties . . . excellent weaving or other forming characteristics? There's a good chance you will find the material you need among the more than 20 grades of stainless steel we fabricate into high quality Fine Wire. No other family of metals has the combination of properties common to the stainless steels.

Learn more about the interesting properties and applications of our stainless steel Fine Wire, as well as our stainless Rod and Strip . . . send today for a copy of our new 40 page Stainless Steel Design Handbook.

ALLOY METAL WIRE DIVISION

HKP

H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

Personals . . .

Robert F. Bourne will serve in a newly created position as director of sales for national accounts of the Colorado Fuel and Iron Corp., and will maintain headquarters at the corporation's sales offices in Wilmington, Del. Mr. Bourne joined C. F. & I. in 1946. He has also served as manager of export sales and manager of rolled product sales for the Colorado division. Mr. Bourne was previously employed as an engineer with the Bureau of Reclamation on the design of dams and power plants in the west. A graduate of Catholic University, he has also worked with the Federal Power Commission in Washington, D. C.

Gilbert C. Mott, chief industrial engineer of Bridgeport Brass Co., Bridgeport, Conn., has been appointed director of engineering. A graduate of Massachusetts Institute of Technology (B.S.), Mr. Mott joined Bridgeport Brass in 1937 as a trainee and served successively as a technical assistant in the tube mill, time study engineer and junior mechanical engineer before his enlistment in the U. S. Navy in 1943. Discharged in 1946, he became process engineer for Bridgeport, and in 1954 was appointed chief industrial engineer. **John F. Kiernan**, chief plant engineer, has been appointed chief engineer of Bridgeport Brass. A graduate of Wentworth Institute of Boston, Mr. Kiernan joined the company in 1936 as a mechanical engineer and became chief plant engineer in 1950.

Joseph Japka is now welding engineer in the materials laboratory, Aircraft Gas Turbine Development Dept., General Electric Co., Cincinnati, Ohio.

Theodore B. Wilk has been appointed technical representative for the northern Ohio district of Misco Precision Casting Co., Whitehall, Mich., a division of Consolidated Foundries and Mfg. Corp.

Paul T. Kilhefner, Jr., having been released from active duty in the U.S. Navy, has accepted a position as metallurgical trainee with the Duquesne, Pa., works of United States Steel Corp. Mr. Kilhefner was a 1952 graduate in metallurgy from Pennsylvania State University.

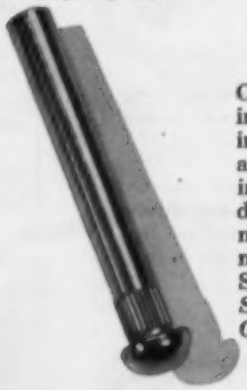
CHECK THE ADVANTAGES OF STAINLESS STEEL FASTENERS

✓ for boosting product quality!

Where appearance and performance call for quality parts, don't overlook the advantages of stainless steel fasteners. Take the illustrated E. W. Ferry fasteners, for example. They're priced right in line with quality fasteners of other materials. Yet they offer all the extra qualities stainless steel brings to any part — high tensile strength . . . attractive, rust-resisting finish . . . and remarkable resistance to heat and corrosion. In almost any application they outlast, many times over, fasteners of nonresistant or plated metal. They cut maintenance costs, too. For even after years of service, disassembling rust-free stainless fasteners is always a fast, easy operation.

✓ for reducing production costs!

The hardness of stainless steel fasteners results in substantial savings on the assembly line. Work is faster, results are better — simply because stainless screw-heads are less apt to burr and nick. This means major savings, for even a slipping screwdriver can seriously damage both the screw and the parts being assembled. Stainless steel fasteners cut tooling costs, too. For they are now available in practically every size and description.



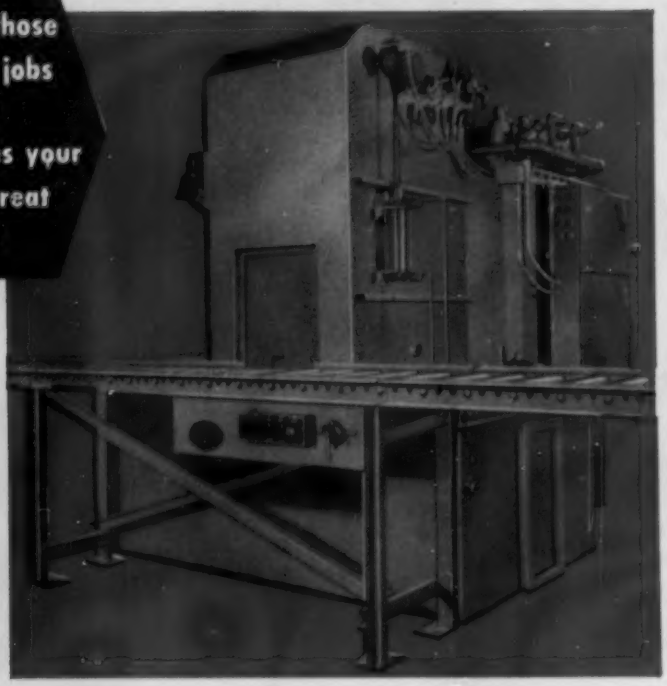
Crucible now offers stainless fastener wire in all diameters . . . in suitable tempers . . . in a variety of finishes, including bright and several metallic and nonmetallic coatings . . . in all standard grades. For prompt delivery of the stainless steel wire you need — or for your free copy of Crucible's new, 32-page catalog "Rezistal Stainless Steel Wire" — call or write to *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

DOW'S "J-800" MODEL

Licks those tough jobs
•
Slashes your heat treat costs!



"NO-GAP" OPERATION—A batch type furnace with less than 30 seconds between loads. Work chamber is never exposed to air. Loading is accomplished while slow cooling or quenching a previous load.

GREATER PRODUCTION—Actual field operation has proven conclusively that the Dow Model J-800 will easily bring 800 pounds from room temperature to 1500° F in less than one hour.

COMPACT CONSTRUCTION—Occupies floor area of only 7'10" x 14'4" giving maximum production for minimum floor space.

VERSATILITY—Ideal for carbonitriding, gas carburizing, clean hardening and carbon restoration. Hot oil quenching and atmosphere cooling equipment available.

EXCLUSIVE FEATURES—High capacity fan combined with heat capacitor assures uniform case depth throughout each load • Forced circulation of quench oil assures uniform hardness with minimum distortion • Sealed quench tank gives cleaner stock—minimizes fire hazard.

DOW FURNACE COMPANY

Quality is your best investment

12045 Woodbine Ave., Detroit 28, Mich.
Phone: KEnwood 2-9100

Personals . . .

Andrew E. St. John has been appointed technical manager of Barth Smelting Corp., Newark, N.J. Mr. St. John was formerly president and treasurer of Alloys and Products, Inc., New York.

Albert J. Smith has been appointed sales manager, electrode division, McKay Co., Pittsburgh. Mr. Smith has served as a metallurgical engineer in the technical service division of the company, and prior to his present appointment was assistant sales manager of the electrode division. He holds a degree in metallurgical engineering from the University of Pittsburgh.

John L. Hartz, chief metallurgist for the Parish Pressed Steel Div. of Dana Corp., Reading, Pa., was recently the recipient of special honors from the company when he was presented with a memorial plaque honoring his 42 years in their employ without a day of absence from work. Mr. Hartz joined the Parish Div. in 1911, after having been associated with E & G Brook Iron Co., Birdsboro, Pa. Present when the plaque was presented was **Howard S. Lewis**, retired president of Parish Pressed Steel, one of the earliest members of the Lehigh Valley Chapter of .

Gordon H. Moline, formerly supervisor of the General Motors Corp. metallurgical laboratory at Kansas City, Kans., is now assistant manager of the Kansas City plant of Metallurgical, Inc.

Thomas A. Foss has been made assistant superintendent, rail accessories division in charge of the spike division, Inland Steel Co., Chicago. Mr. Foss was formerly general foreman in the spike division, and is secretary of the Calumet Chapter .

Charles E. Vest, formerly aircraft research engineer for Lockheed Aircraft Corp., Marietta, Ga., has accepted a position as supervisor of final assembly at the reactor fuel fabrication plant of Babcock & Wilcox Co., Lynchburg, Va.

Damian V. Gullotti has accepted a position as research assistant at Ohio State University, and is also working towards a master's degree in metallurgy.

It's Fast
It's Thorough
It's Economical

It's your Best Buy in Degreasing Agents!

Nialk® TRICHLORethylene

When you stack up all the advantages offered by Nialk TRICHLORethylene you'll understand why more and more companies are standardizing on it for metal parts degreasing.

Versatile—the ideal organic solvent for removing practically every kind of foreign matter—waxes, greases, oils, gums, tars—even chips. Leaves parts clean, warm, dry, ready for assembly, inspection or surface treatment.

Fast—Acts quickly, cleans and dries rapidly. Its low boiling point (86.6°-87.8°C, based on standard ASTM tests) permits vaporization at low steam temperatures.

Thorough—Low viscosity (0.58 centipoises at 20°C) and low surface tension (about 29 dynes per cm at 30°C) assure diffusion into pores and relatively inaccessible openings.

Economical—Stable and completely usable after distillation. Cuts power consumption . . . can be heated by gas, steam or electricity. Gives concentrated vapor at only 188°F. Specific heat is less than ¼ that of water. Cuts vapor loss—high vapor density (4.5 times that of air) assures proper vapor level at all times.

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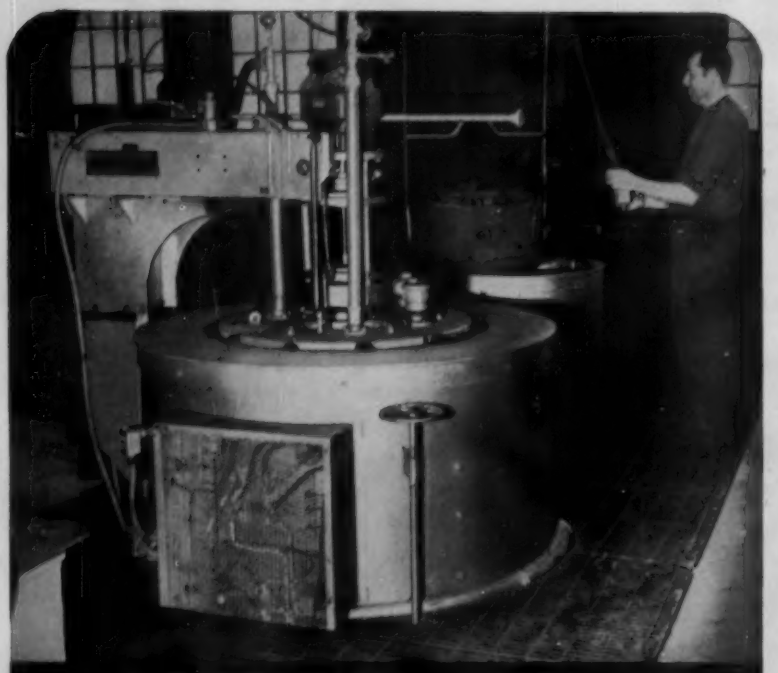

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FURNACE

Electrol Inc., manufacturers of hydraulic devices, carburizes landing gear orifice tubes in 3 hours instead of 7 hours formerly required by the pack method.

Edgar B. Roesch, Factory Manager, says, "With this Hevi Duty Retort Furnace, we can produce a more uniform case faster because —

Forced Circulation assures even case depth throughout the densest loads.

Zone Temperature Control helps bring the load up to temperature more quickly and evenly.

Positive Pressure inside the retort has simplified the obtaining of exact carbon concentrations on the surface of the work and to specified depths."

The carburizing atmosphere is supplied from a Hevi Duty Endothermic Generator to which natural gas is added. This atmosphere protects the work from scaling which results in a further saving of 50% in surface finishing time.

Write for Bulletin HD-646-R and more information about how the Hevi Duty Retort Furnace is used for carburizing, hardening, nitriding, and bright annealing.

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Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers *Constant Current Regulators*

Personals . . .

Lathan C. Jackson, who has been employed as metallurgist and laboratory supervisor in the oil tool division of Chicago Pneumatic Tool Co., Fort Worth, Tex., is now product methods engineer, metallurgy department, Sperry Farragut Co., Bristol, Tenn.

Karl A. Elers, formerly manager of product development and engineering service for Allegheny Ludlum Steel Corp., Pittsburgh, has been appointed Pacific Coast area manager. Mr. Elers has been with the corporation since 1930, and for nine years was assistant district manager in the Chicago area. **Irving R. Leheney**, also with Allegheny Ludlum and formerly assistant product manager, becomes toolsteel product manager. **John B. Henry, Jr.**, manager of the company's architectural division, has been appointed acting manager of application development for the firm.

Raymond A. Quadt, director of research and development of Hunter Douglas Corp., Riverside, Calif., has been promoted to assistant vice-president. Mr. Quadt will also continue the duties of his former post and be responsible for commodity sales. He was formerly employed as director of aluminum development by the Federated Metals Div. of American Smelting and Refining Co., Barber, N.J.

W. G. Leaman has been appointed manager of the new direct-sales office and warehouse of General Electric Co. in Buffalo, N.Y.

William B. Larson, who has been serving in the U.S. Army for the past two years, is now employed at the research laboratories division, metallurgy department, of General Motors Corp., Detroit, a position he held for a short time before entering the service.

Simon Feigenbaum is now chief industrial engineer for Jones & Laughlin Steel Corp., Pittsburgh.

Henry J. Albert, who graduated from Massachusetts Institute of Technology with a D.Sc. degree in June, is now employed in the research laboratory of Baker & Co., Newark, N.J.

Type 316

No. 7-Mo

How Can Corrosion Control Service Like This

Pay Off For You ?

No doubt about it . . . your corrosion problems are different. In working with plant after plant we know this is true. We also know that one of the phenomena of corrosion resisting steels is that there doesn't seem to be a cure-all. This is exactly why we have equipped ourselves, through constant laboratory research and field work, to render a truly helpful corrosion control service for plants like yours. This service includes development of totally new steels such as Carpenter No. 20, a super corrosion resisting stainless that comes closest to providing the answer to economical handling of a wide range of chemicals, including hot sulphuric acid.

What's *your* corrosion problem? Perhaps Carpenter's Corrosion Control Service, backed by experienced metallurgists, can help solve it. Take time now to drop us a line on your company letterhead. At no obligation, we'll be glad to work with you.

SOLVED | **A Tough Problem in Handling NITRIC-HYDROFLUORIC ACID**

Problem: While nitric and hydrofluoric acids are relatively easy to handle separately by certain alloys, the combination of both presents a tough corrosion problem. An eastern plant was using Stainless Type 316 for baskets, racks, etc., in a pickling process involving a solution of nitric-hydrofluoric acid. The concern was running up against costly problems caused by fast deterioration of the equipment. Then they threw the problem in Carpenter's lap. We worked closely with them right from the start . . . supplied test samples of several Carpenter Stainless grades.

These were inserted in the solution (17% nitric acid, 6½% hydrofluoric acid) under actual operating conditions. Part of each specimen was held in the quiescent portion of the solution . . . and part of each was exposed to the aerated condition. They were exposed continuously, to the same medium encountered in normal operation, for a period of 117 days.

Statistics: *Agitation:* None *Temperature:* 70 to 130°F *Contaminants in Bath:* chromium, iron, nickel salts, along with a sludge of metallic oxides.

Of the samples tested, Carpenter No. 7-Mo provided the best results. For example, here are results in loss of metal comparing Stainless Type 316 with No. 7-Mo:

Loss of metal, in inches per month:

No. 7-Mo	.0009 ipm
Type 316	.0074 ipm

These results indicated to the concern that baskets and racks made from Carpenter No. 7-Mo will last *eight times longer* than those made from Type 316.

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Personals . . .

Paul Totta has completed the G.E. chemical and metallurgical training program and is permanently employed in the advanced development unit of the metallurgical subsection in the laboratory of General Electric Co., Fort Wayne, Ind.

Harry J. Gilliland has been transferred from the Buick-Oldsmobile-Pontiac Div. of General Motors Corp., Kansas City, Kan., to Detroit, and a new assignment as the senior metallurgist for the process and development section at the new General Motors Technical Center.

John D. Sprowl, formerly with General Electric Co., Richland, Wash., is a research engineer in the metallurgical research department of Kaiser Aluminum and Chemical Corp., Spokane, Wash.

John Billings has resigned as senior metallurgist of Auro Aircraft, Ltd., Malton, Ont., to accept a position as chief inspector of Western Canada Steel Co., Vancouver, B.C.

Ray A. Dyke, Jr., formerly metallurgist for American Cast Iron Pipe Co., Birmingham, Ala., has been appointed foundry metallurgist of Central Foundry Co., Holt, Ala.

B. E. Yarotsky recently resigned as program development engineer at Armour Research Foundation, Chicago, to accept an assignment as assistant to the director of research and development at Crucible Steel Corp. of America, Pittsburgh.

Durmus Attila is now a metallurgical technician for Budd Co., Philadelphia.

Virgil Knierim has accepted a position as assistant development engineer with the Bridgeport Brass Co., Adrian, Mich.

Alfred D. Stevens is manager of quality control for Valenite Metals Corp., Detroit. Mr. Stevens is responsible for grade development and technical customer relations in addition to quality control.

Clayton W. Blough is an industrial sales representative for the Akron, Ohio, division of East Ohio Gas Co.

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Lithium has been long established in the nonferrous foundry industry as a degasifier, deoxidizer, desulfurizer and general purifying agent, particularly for high conductivity copper castings and copper-base alloys. The small amounts required put both the economics and technique within the limits of everyday nonferrous foundry operation. Research now under way suggests that Lithium is equally valuable as a degasifier for aluminum castings. Further extensive research on various Lithium Salts holds vast promise of valuable benefits to be gained for low temperature heat treating baths. Why don't you look into this miracle element? This revolutionary technique is within *your* reach. Write for details.

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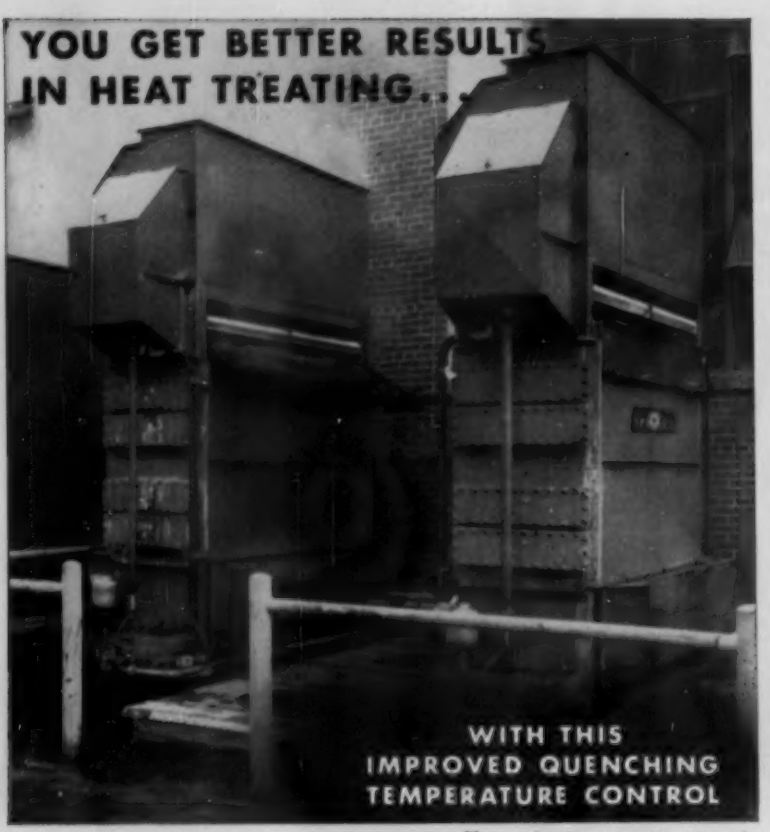

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For further information write for Bulletin No. 120

NIAGARA BLOWER COMPANY

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District Engineers in Principal Cities of United States and Canada

Fatigue of Spot Welds*

THE USEFULNESS of spot welding for joints that will be subjected to varying loads in service is severely limited by the surprisingly low fatigue strength of such joints. In applications such as automobiles, ships, railway carriages and airplanes, riveted joints are more durable than spot welded joints. This paper summarizes ten years' study by the Fatigue of Spot Welds Committee of the Welding Research Council to determine methods of improving fatigue strength.

Under fatigue loads only about 16% of the average static shear strength of spot welded aluminum alloys can be attained in single spots, and double spots seem to support even less than 10% of the average shear strength. Hess in 1946 found that for a fatigue life value of 5,000,000 cycles, the range of stress at point of failure is about 13 to 15% of the average static shear strength (the type of loading applied to these specimens consisted of a pulsating tensile stress on the sheet, superimposed on a steady tensile stress amounting to 10% of the average static shear strength).

In a paper on aluminum alloys Forrest reports that the fatigue strength of single-spot welds of Alclad sheets (DTD 546 A) 0.036 in. thick at 20,000,000 cycles is about 12% of the ultimate shear strength. After preloading these welds with a static load, equal to two-thirds of the average static stress at point of failure, the fatigue strength is about 18% of the ultimate static shear strength. Completely reversed fatigue tests of Alclad 2024-T (24 S-T) alloy spots of 0.064-in. thick sheets at 10,000,000 cycles give an average load of only 50 to 60 lb. per spot; this fatigue limit represents less than 10% of the static shear strength. The endurance limit for aluminum alloy 3003 (3 S) spot welded sheets 0.064 in. thick, subjected to complete reversal of stress, has been found to range from 9 to 13% of the static shear strength. These ratios are not as great as those

(Continued on p. 146)

*Digest of "Fatigue of Spot Welds", by Georges Welter, *Welding Journal* (Welding Research Supplement), Vol. 20, March 1955, p. 153s-156s.

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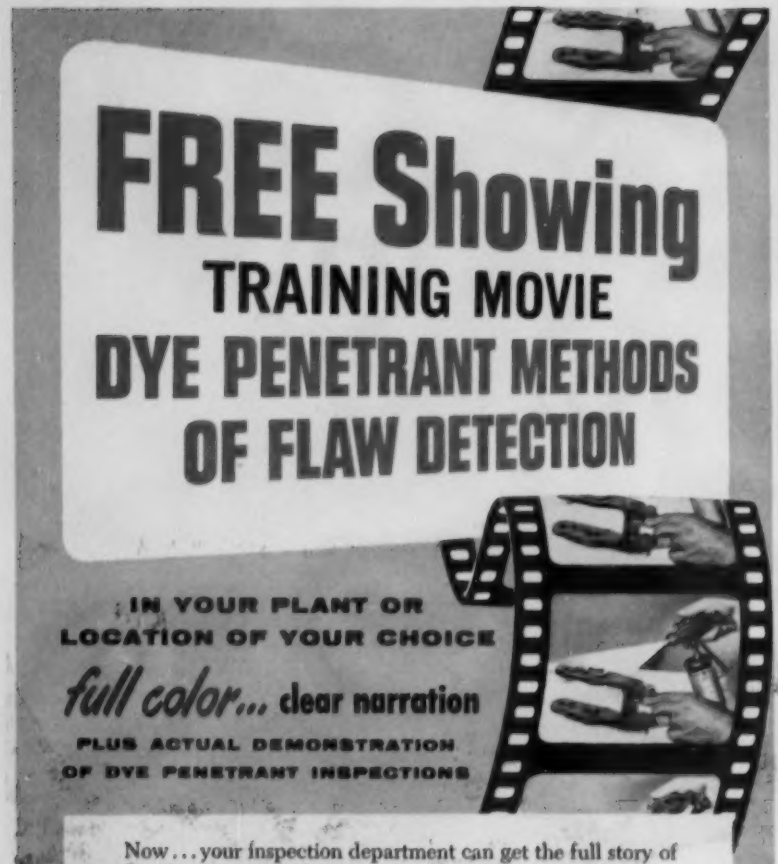
So when you need prompt delivery of *any* kind of cold rolled specialty steel *call Crucible.* Experienced Crucible metallurgists can help, too, in selecting the *best* steels for your job. And write for your free copy of Crucible's new 32-page booklet on cold rolled specialty steels. It's packed with useful data. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America



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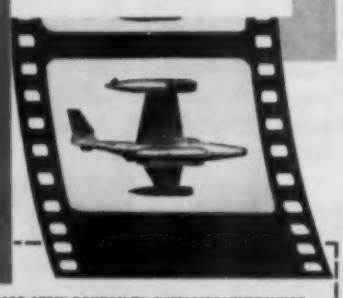

Attention: AIRCRAFT—METAL-WORKING PLANTS!

SEE... Production-line inspection of wing spars

SEE... In-lathe inspections without disturbing set-up

SEE... Location of weld porosity in pressure vessels

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Spot Welds . . .

normally obtained for riveted lap joints in aircraft materials.

In a preliminary test series carried out at Ecole Polytechnique in 1946 and 1947 it was found that the number of cycles absorbed by specially treated specimens was 10 to 12 times greater than that of untreated specimens tested under the same load.

The treatment for the improvement of electrically welded joints consists principally in a mechanical process by which extremely high pressures are applied to the weld after the welding operation is accomplished and the weld has cooled down to room temperature. The pressure applied over the whole area of the weld is of the hydrostatic type and exceeds the elastic limit of the weld appreciably. (Pressure is applied only to the surface at the spot, but by using a jig which prevents movement of the sample, a three-dimensional, or hydrostatic, pressure system is set up.) By this mechanical high-pressure treatment the weld in the fused area of the spot is changed from a cast and annealed crystal structure into a wrought and cold worked material of much better mechanical properties, especially fatigue resistance. Also the numerous imperfections in all cast metals and alloys, such as cracks, fissures, porosity, pinholes, segregation and harmful residual stresses, are greatly reduced in the weld by this process. Starting with compression loads of about 86,000 psi., they were gradually increased to 230,000 psi. Fatigue strength increased with increase in pressure and it is possible that heavier pressures would continue to improve fatigue strength up to some maximum value.

The exceptionally high hydrostatic pressure, as applied to the welds during this investigation, seems not to improve appreciably their static resistance in tension. Fatigue tests carried out on two different types of pulsators are in fairly good accord, indicating that the fatigue load of mechanically treated specimens can be increased materially without sustaining failure of any welded Alclad 2024-T (24 S-T) aluminum alloy samples. The untreated samples, however, for which the lower fatigue limit could not be

(Continued on p. 148)

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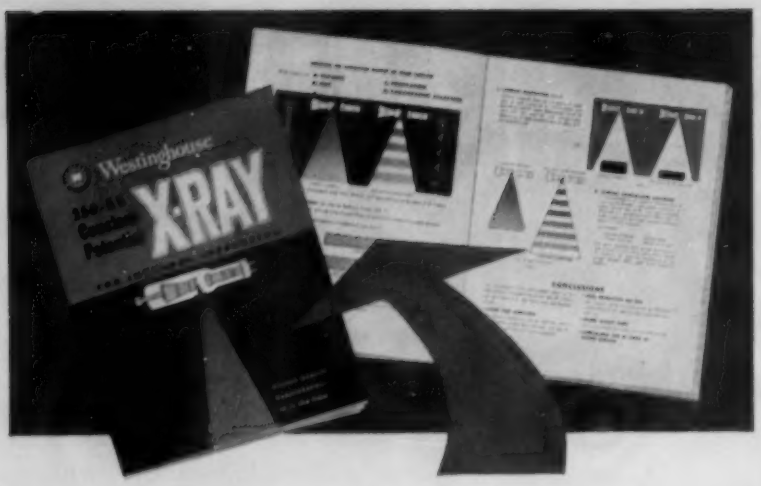
Charlotte†	Denver	Kansas City, Mo.	New Orleans	Rochester†	(†sales office only)



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J-08305A

Spot Welds . . .

established, failed under a fatigue load of only 300 lb. after a few hundred thousand cycles. This endurance load should be, according to previous results, about 10 to 16% of the ultimate static load, which may in this case represent repeated loads of about 100 to 200 lb. Hydrostatically compressed welds loaded from 0 to 650 lb. maximum tension did not fail under repeated loads of several million cycles. The limit of cycles for these tests was between 4,000,000 and 5,000,000. In one special case this load has been repeated 29,000,000 times without any visible change in the welded spot. From these results, the following conclusion has been drawn: An improvement of about 250 to 300% of treated spots seems possible.

Under high compression loads of about 15,000 to 20,000 lb., applied with a ram ¾ in. in diameter, representing a maximum of about 400,000 psi., an improvement of the number of fatigue cycles of two to three times has been recorded on two different pulsators under pull-pull loads of 500 to 760 lb., applied to welded mild steel specimens.

Stainless steel specimens (18-8 Cr-Ni) 0.03 in. thick, ¼ hard, supported a higher repeated load up to failure than mild steel specimens; under 650 to 770 lb. the treated specimens were generally more resistant and, after mechanical treatment, cycles of three to ten times those of untreated specimens could be recorded.

In 1950, two papers about the stresses distributed around spot welds were published, one by the Franklin Institute of Philadelphia, and the other one by the Research and Strength of Materials Laboratory in Montreal. The findings of these two reports can be summarized as follows: Single laps of spot welded joints are inherently weak due to the unavoidable bending of the plates; in important structures double laps (one plate sandwiched between two plates) will reduce considerably the high stress concentrations set up at the weld spot; joining of two plates by one row of resistance spot welds is inherently unsound when used for structures carrying greatly variable loads or reversal of stress.

(Continued on p. 150)

CLEANING SPECIALISTS

give you a "brighter" outlook on life.

It's amazing how pleasant the view can be after one of these steel-nerved, sure-footed, alert Cleaning Specialists have done their job.

Northwest's Metal Cleaning Specialists are "alert" to your problems when it comes to giving your products a "brighter" outlook. Day in—day out, Northwest carries on the constant search for better, lower cost, analytically-correct cleaners to give you dependable, good looking, permanent finishes.

Remember —YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER

From Northwest's years of experience in developing job-adjusted cleaners for your specific needs have come such processes as the LO-HI pH—for cleaning prior to plating, painting or vitreous enameling; ALKALUME—for preparing aluminum for finishing and spot welding; INTERLOX—for phosphate coating; SPRA-LUBE—to control over-spray of "today's" paints in water wash paint booths; PAINT STRIPPERS—specific to your needs; SUPER-DRAW & FLUID FILM—for drawing metals.

Northwest's production-tested chemicals and "Right-the-first-time" recommendations will save you money. Northwest Service is as close as your phone.

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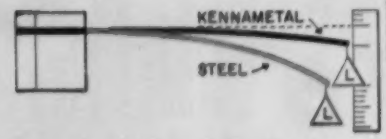
Here's an important message for Y·O·U· about Y·M·E·

YME—Young's Modulus of Elasticity—is one of the most important characteristics of any metal used in structural components of machines used for precision work. It determines the extent to which those parts will deform under a given load.

• • •

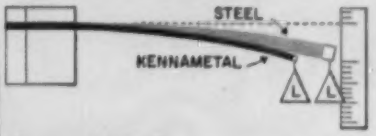
Same deflection—greater load

Put another way, the high YME of Kennametal means that you can load Kennametal parts about three times as much as similar parts made of steel . . . an important factor in precision work.



Same load—less deflection

No substance is without deformation under load, but Kennametal* deflects less than 40% as much as the hardest steel, because the YME of Kennametal is near 90 million psi while that of steel is approximately 30 million.

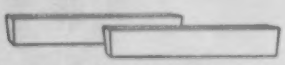


Same deflection—same load —less material

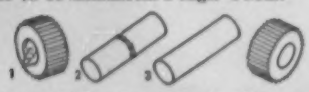
Or, if deflection and loading are acceptable, a Kennametal part will require less material. Thus, machine elements may be miniaturized—with an attendant increase in economy, compactness and convenience.

. . . here's how designers have interpreted the YME of KENNAMETAL* to their problems

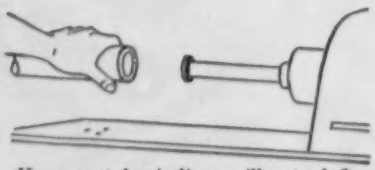
The following are a few instances where designers solved production problems with Kennametal because its high YME, plus its high density, minimizes deflection, chatter, weaving, wear and dampens vibration.



An automotive manufacturer, for example, switched to solid Kennametal for grooving tool blades used in cutting piston ring grooves in aluminum alloy pistons . . . jumped cuttings between resharpenings from 800 to 18,000 pistons. Apparently, the longer wear resulted from the elimination of weaving due to Kennametal's high YME.



Kennametal pins for knurling tools showed no wear or deformation (fig. 3) under increased production speeds and feeds, which shattered the steel pins generally used (fig. 2; steel pin imbedded in knurl, fig. 1).



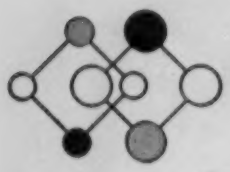
Kennametal grinding quill cuts deflection, speeds up the grinding of I.D. of cylinder liner for plastics compressor, and provides greater accuracy of machining.

Perhaps the answer to your "idea problem" is here, too

This characteristic high YME of Kennametal, in addition to its extreme hardness, high strength and resistance to corrosion and abrasion, is being utilized to great advantage in a variety of applications. Perhaps it can be the means of getting YOUR idea into production. Why not send for additional information? Write to KENNAMETAL INC., Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

5557



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Spot Welds . . .

Test results concerning the development of fatigue cracks under cyclic tension load show that these cracks start at the interface of the weld, due to repeated bending of the sheet in a zone close to the spot. These cracks develop a long time before they become visible at the outside surface of the sheet.

Fatigue results obtained with mild steel specimens 0.04 in. thick, obtained on three different pulsators, show that hydrostatically treated spots have a 25 to 50% higher fatigue limit than untreated joints. Similar results have been obtained with spot welded, 0.03-in. thick stainless steel sheets. Hydrostatic compression of the spot is even more effective on 2024-T (24 S-T) Alclad sheets; an improvement of 80 to 100% of their endurance limit is possible.

The hydrostatic treatment of multiple spot welded joints has, as for single spot welds, a marked influence on their fatigue limit. By a hydrostatic compression of multiple joints of about 150,000 psi. in the area of the spot, an improvement of about 80 to 100% of their endurance limit has been obtained. Better results should be possible by a careful study of the optimum hydrostatic pressure and the best possible shape of steel piston used to produce the compression. After hydrostatic treatment, these joints have a fatigue limit which is an acceptable relation to the ultimate load under fatigue, approaching that of other structural materials.

Much higher fatigue results have been obtained with hydrostatically treated Cor-Ten specimens. After a compression of the spot under a load of 15,000 lb., the fatigue limit at 10 million cycles has been brought up to 1200 lb., compared to 400 lb. for the untreated specimens. The improvement by hydrostatic compression is 200%.

For multiple-spot welds, similar improvements have been found, which decrease, however, with the number of spots. For two spots in vertical arrangement, there is an improvement of about 150%, while for a five-spot sample, there seems to be only a 50% improvement of the load at the endurance limit.

The 10-million-cycle fatigue limit

(Continued on p. 152)

"Spotty Hardness Curtailed Production..!"

A short time ago, a very large Midwest machine tool manufacturer called on Sinclair to solve a quenching problem. They wanted to eliminate a spotty hardness condition, and also to stop heat-treat fires in a continuous furnace of 800 lb. per hour capacity.

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> Higher hardnesses (QUENCHOL 521 increased the hardness of 1038 steel bolts, 1" x 10½", from R_C 20-22 to R_C 45.)."

"I might add, this company is now using QUENCHOL 521 – 100% with substantial savings through a low piece rejection rate," concludes Mr. Smith.

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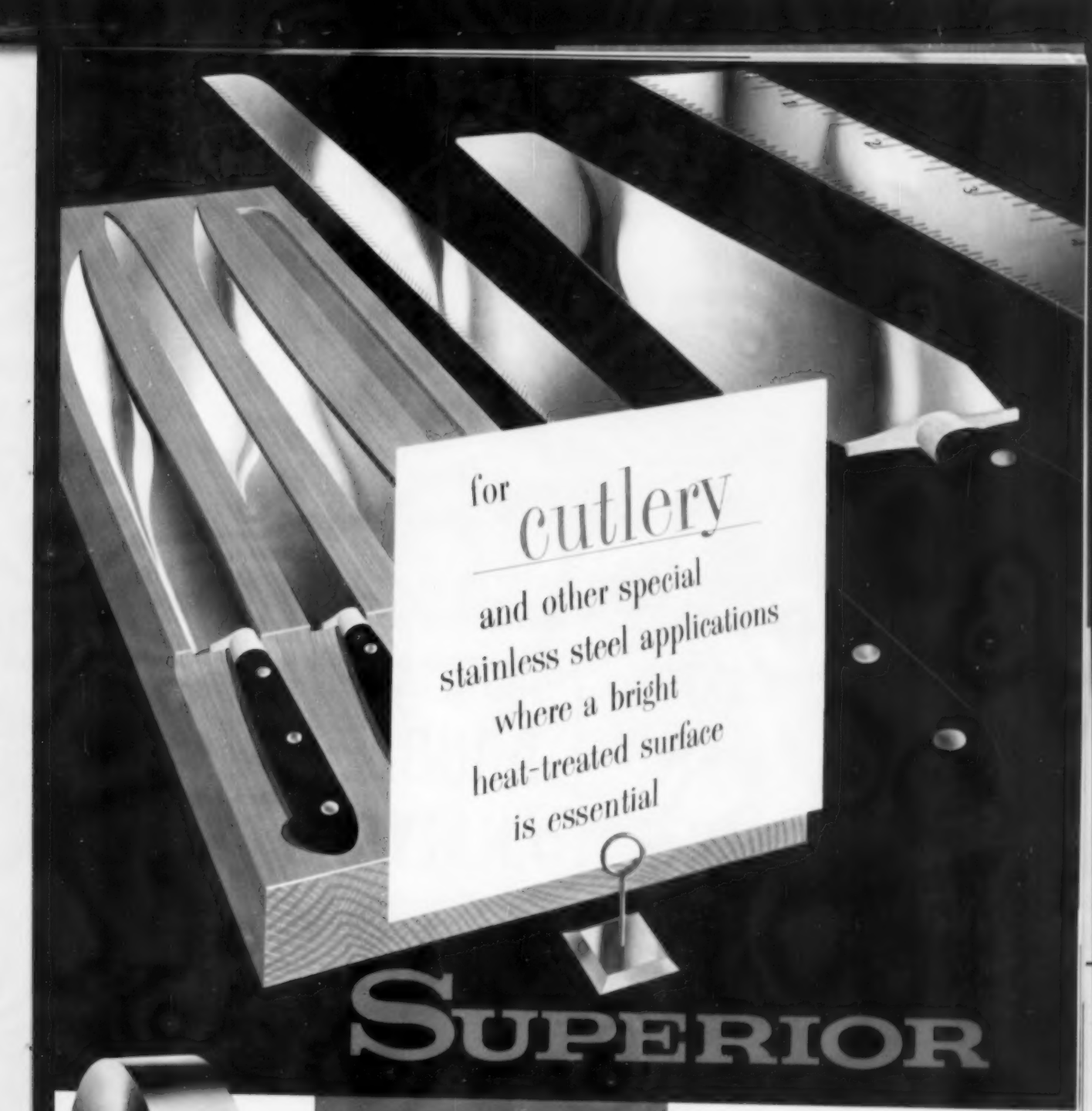
Spot Welds . . .

of Cor-Ten joints with 1 to 5 spots in the as-received condition is of the order of about 12 to 18% of the ultimate shearing load. After hydrostatic treatment of the joints an improvement of the fatigue limit of about 50 to 200% has been found. On a load-per-spot basis, the fatigue limit decreases with the number of spots per joint; this load for a one-spot specimen is about twice that of the load for three, four and five-spot specimens.

In a more recent comprehensive laboratory work carried out in 1951-52 (reported upon by V. N. Krivobok, *Welding Research Supplement*, October 1954) multiple stainless steel 18-8 spot welds with and without hydrostatic treatment have been tested under static and cycle loads. The results obtained in this work have been summarized as follows: *(a)* For stainless steel sheet as-spot-welded; as the number of spots per sample is increased, the load per spot for failure through fatigue is decreased. *(b)* The location of the fatigue crack in the as-spot-welded tests was never in the weld button but in the heat-affected zone of the parent metal. There is no correlation between fatigue and shear strength. A comparison of tensile (shear) and fatigue strength is not warranted, since in one case the values are representative of cast metal (weld nugget) and in the other case the values represent the resistance of heat-affected (annealed) sheet material to failure through fatigue. It has been confirmed, however, that the strength of the spot welded joints tested in fatigue when compared to the strength of similar joints tested in straight tension is very low. *(c)* Hydrostatic prestressing shows a definite improvement in fatigue properties over untreated specimens and this improvement exceeds that observed on other materials tested under similar conditions. This is the case regardless of the number of spot welds prestressed in one treatment. *(d)* Simple compression of the spot welds produced a considerable improvement in fatigue over uncompressed samples of the same material. *(e)* Similar improvement in fatigue characteristics could also be gained by prestressing by means of tension or peening. J. T.



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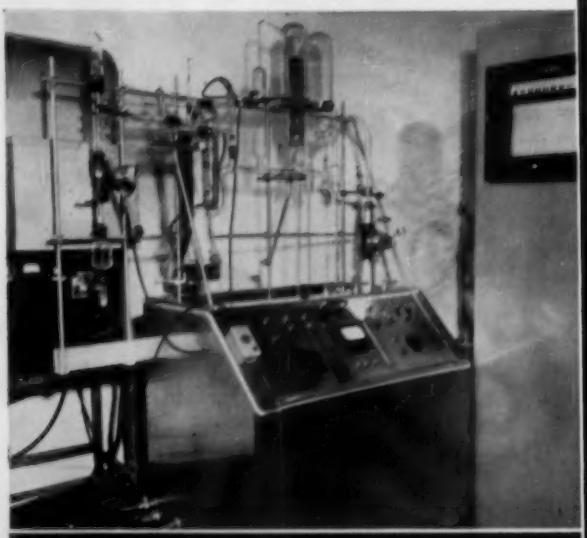

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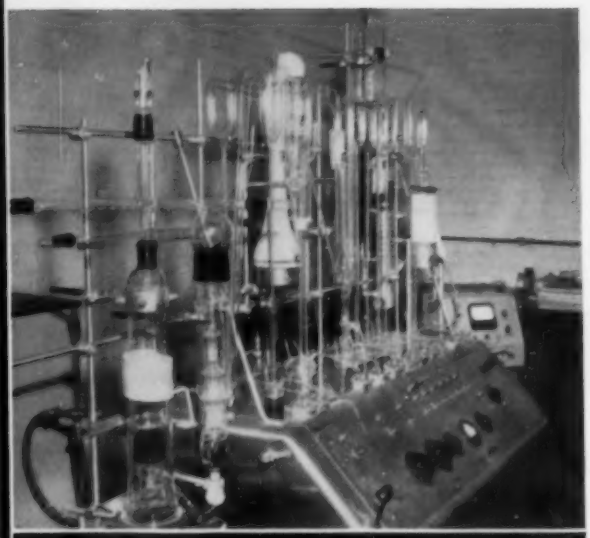

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Improved Standard Vacuum Fusion Gas Analyzer can

DOUBLE No. of ANALYSES per week

This apparatus is the accepted standard for accurately determining the amount of oxygen, nitrogen and hydrogen in the range of 1 to 10,000 ppm by weight in a wide variety of metals and alloys. Model 912 now has two removable furnace assemblies. By cleaning one while the other is outgassing, down-time is reduced. Improved halogenated graphite cuts outgassing time. The resulting reduction in make-ready time can double productivity for some metals such as titanium. NRC analysts install and calibrate equipment and instruct operator.

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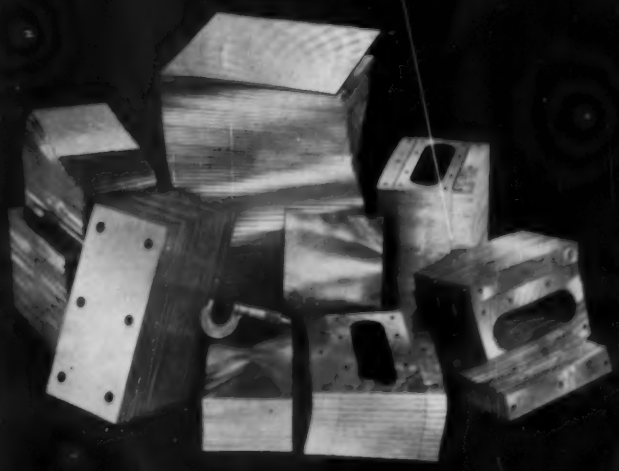
*brick mold liners, for example



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Properties of Titanium at Low Temperature*

A STUDY was made of some of the mechanical properties of annealed commercially pure titanium to evaluate the effect of low temperatures on the tensile and impact properties and on the true-stress, true-strain relationship. The range investigated extended from −196 to 100° C. (−320 to 212° F.).

The strength and the rate of work hardening of both notched and unnotched tensile specimens generally increased as the temperature was lowered within this range. Increases in strength and rate of work hardening were greater for notched than for unnotched specimens. Greater increases were found for deep notches than for shallow notches. This was attributed to the multi-axial stresses induced by the notches.

The ductility of unnotched titanium was not impaired by lowering of the test temperature. The ductility of notched specimens was much less than that of unnotched specimens at the same temperature. In addition, deep-notched specimens showed greater ductility than shallow-notched specimens. The greater ductility of the deep-notched specimens indicated that stress concentrations and stress gradients are more important than multi-axial stress in controlling the ductility of titanium.

True-stress, true-strain curves for the entire temperature range are presented for unnotched specimens. The initial resistance of titanium to plastic flow is increased greatly with decrease in temperature, being more than twice as great at −196° C. (−320° F.) as at 100° C. (212° F.). It was shown that the relationship between true stress and true strain for metals deformed in tension cannot be represented by $\sigma = b\delta^m$, where σ and δ represent true stress and true strain, respectively, while b and m are constants. No truly representative values for the strain hardening exponents m could be established from the data obtained.

The influence of temperature on true stresses is shown by plotting the true stress at a given true strain to a logarithmic scale against the temperature. The relationship is approximately linear and may be represented approximately by

$$\sigma_\delta = \text{constant} = Ae^{-kt}$$

where t is the absolute temperature, σ_δ is true stress at constant strain, and k and A are constant for a given true strain. Other experimental verification is required before this relationship can be established as a fundamental law.

To determine the influence of prior strain-temperature history on true-stress, true-strain relations, two-stage tensile tests were made. A specimen was extended in the first stage of a test at 24° C. (75° F.) to a true strain just beyond the true strain at maximum load and subsequently extended to fracture in the

(Continued on p. 156)

*Digest of "Effect of Low Temperature on the Mechanical Properties of Commercially Pure Titanium", by G. W. Geil and N. L. Carwile, *Journal of Research* of the National Bureau of Standards, Vol. 54, February 1955, p. 91-101.

5-Day Course

TITANIUM METALLURGY

conducted by

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AMERICAN SOCIETY FOR METALS

University Heights Campus—New York University

September 12-16, 1955

The Department of Metallurgical Engineering of the College of Engineering, New York University, and the Office of Special Service to Business and Industry, in cooperation with the newly-formed ASM Metals Engineering Institute, will conduct a one week course on the metallurgical problems associated with titanium.

Experts in various phases of titanium metallurgy will present a total of 25 lectures in their particular fields. The course will cover extraction, melting, purification, physical metallurgy (alloying and heat treatment), mechanical metallurgy, analysis, corrosion, fabrication problems, and applications.

Monday	Sept. 12	"Applications and Melting"
Tuesday	Sept. 13	"Physical Metallurgy—Phase Diagrams, Metallography and Alloying"
Wed.	Sept. 14	"Heat Treatment and Properties"
Thurs.	Sept. 15	"Mechanical Metallurgy, Corrosion, and Fabrication"
Friday	Sept. 16	"Fabrication and Extraction"

Enrollment fees will be $90.00 for the entire course or $30.00 per day; attendance will be limited. Registrants for the entire course will have priority over one-day registrants.

Dormitory space will be available from September 11 to September 17 for those requiring it at a rate of $2.50 per day.

A brochure giving the details of the five-day program together with the necessary registration forms may be obtained by writing to:

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Titanium . . .

second stage at –196° C. (–320° F.). It was shown that the work hardening at 24° C. (75° F.) was much less on this specimen than the work hardening on a specimen extended to the same true strain at –196° C. (–320° F.) in a single-stage test.

Three main features were exhibited by the data on notched specimens from true-stress, true-strain relations obtained from single-stage tension tests at –196, –78, 24, and 100° C. (–320, –110, 75, and 212° F.). These were:

1. Initial fracture occurred in notched specimens at relatively small true strains compared to unnotched specimens.

2. True-stress, true-strain curves for notched specimens, and especially those for deep notches, were above those for unnotched specimens at the corresponding temperature.

3. The ductility of both deep and shallow-notched specimens decreased with decrease in temperature, whereas the ductility of unnotched specimens remained unchanged.

The experimental results indicate that the transition temperature range for titanium varies with the stress system and the rate of deformation. The transition temperature range was as follows:

1. Below –190° C. (–320° F.) for slow deformation under uni-axial stress.

2. Apparently between –196 and 100° C. (–320 and 212° F.) for slow deformation under multi-axial stress.

3. Between 26 and 300° C. (80 and 570° F.) for rapid deformation under multi-axial stress, as in the impact test on Charpy V-notched specimens.

In designing for titanium to be used at low temperatures, special attention should be placed on the elimination of sharp fillets and small radii at roots of re-entrant angles, and protection against nicks or deep scratches during service.

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This new Cooley GA-3 electric is the first small furnace to provide atmosphere protection with a reasonable investment and low operating costs. The atmosphere is generated by cracking alcohol and water of proportions predetermined to suit the application. Steel may be clean hardened without decarburization, or may be carburized.

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Cooley HEAT TREATING FURNACES

Successful Founding of Mg Alloys*

This series is part of a book entitled "La Fonderie des Alliages Legers et Ultra-Legers" and is published with the permission of the French Air Ministry. The translation was made by L. H. Tripp of Magnesium Electron Ltd.

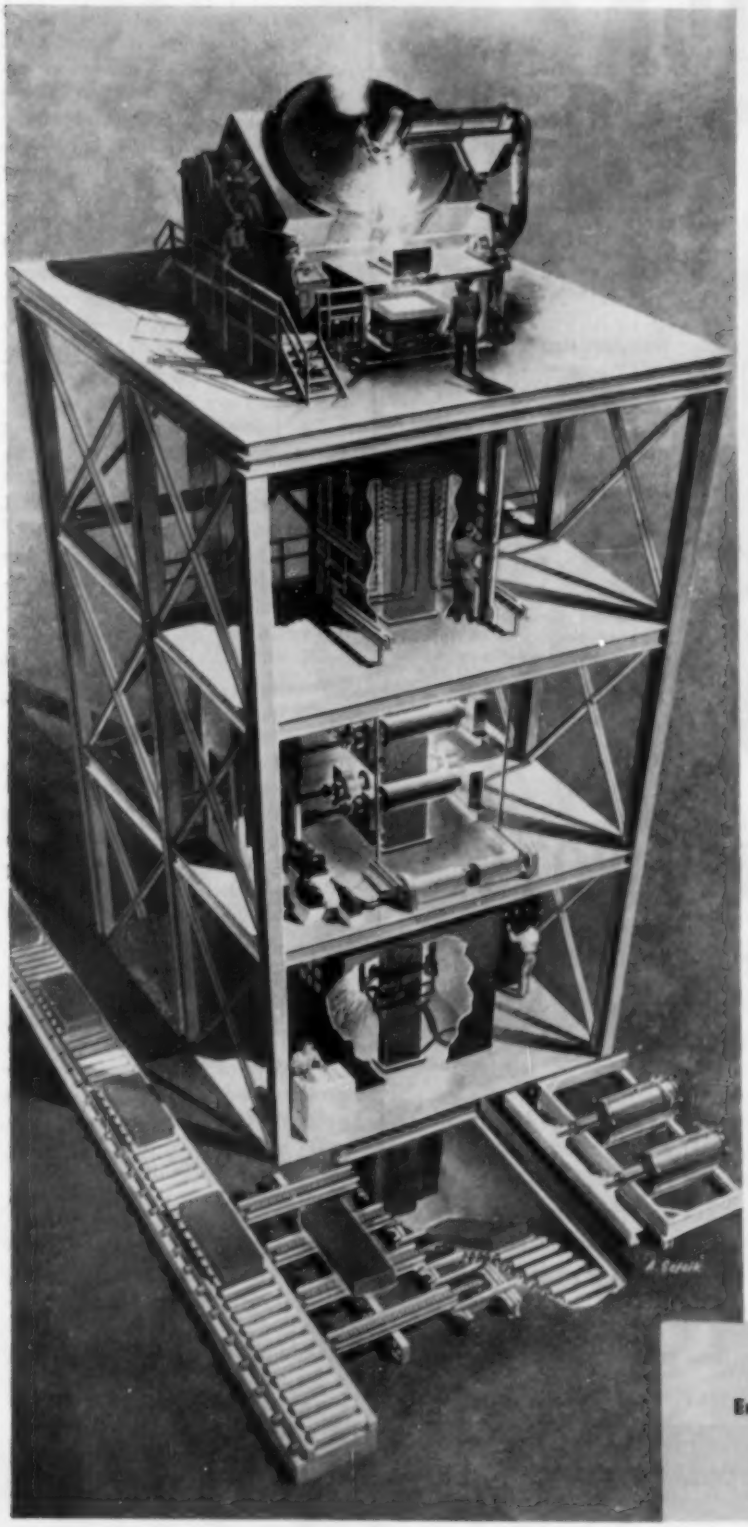
Notwithstanding the fact that the author is dealing with aluminum and magnesium, much of interest and practical value is given that applies equally to all nonferrous metals.

The author first considers shrinkage porosity of magnesium alloys. The following quotation will indicate the basic method of the author's approach and for this reason is given at some length: "Shrinkage porosity is due to insufficient feed metal to offset the reduction in volume which usually accompanies the cooling of a previously molten metal or

(Continued on p. 158)

*Digest of "Founding Magnesium-Base Alloys", by M. Caillon, a series of 17 articles appearing in *Metal Industry*, Vol. 84, from Jan. 1, 1954 to April 23, 1954.

For the continuous casting of steel...



Koppers builds the first commercial-scale machine

The continuous-casting machine illustrated here is now in operation at Atlas Steels Ltd., Welland, Ontario, Canada. This is the first commercial-scale installation in North America that, in a continuous line, converts molten steel into solidified billets or slabs. It was designed and constructed by the Freyn Department of Koppers Engineering and Construction Division.

Atlas Steels' machine is presently producing slabs and billets in three sizes. With different molds, this machine also could produce any desired billet section. It is designed to cast 35-ton heats.

In theory, this new machine could cast a billet or slab of steel many miles in length; it is limited only by the supply of molten metal. In actual practice, acetylene torches automatically cut the molded steel into required lengths as it emerges from the machine.

Continuous casting is an *economical* short-cut in steelmaking. It eliminates the need for ingot-casting and stripping equipment, except the ladle crane. Soaking pits and blooming mills can be by-passed. Also, the Freyn-design continuous-casting process can yield 10 to 15 per cent more finished steel per heat than conventional pouring methods.

Your inquiry is invited concerning the continuous-casting operation . . . or any other metallurgical construction problems you may have. You incur no obligation.

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Magnesium Foundry . . .

alloy. In magnitude it represents the algebraical sum of the shrinkage of the metal in the liquid state and of its contraction during solidification. Were it possible to ensure ideal conditions where no change in volume occurs during cooling, where cooling is isothermal, and where liquid metal can fill the cavities as fast as they form, no such porosity could occur. The first two conditions, being entirely ideal, are not experienced in practice; only the third offers a practical means of overcoming shrinkage cavitation or porosity by replenishing the mold from a reserve of liquid metal until solidification is complete. It is this reserve that constitutes the riser.

"It follows from the foregoing that three factors contribute to the formation of shrinkage voids; these are the change in volume of metal which occurs from the moment of filling the mold until the casting has completely solidified, the temperature gradient, and the feeding conditions in the mold during solidification. The change in volume is determined by the physical constants of the alloy. For the liquid state the change in density is a function of the coefficient of expansion; there is always a reduction in specific volume during cooling. Some figures can be given for pure magnesium. In the molten state prior to solidification it has a specific volume of 0.631, which corresponds to a density of 1.585. After solidification the specific volume is 0.606, corresponding to a density of 1.649. The reduction in volume at freezing temperature amounts therefore to 3.97%. At room temperature the specific volume is 0.573, representing a density of 1.745 and a decrease in volume of 5.46%."

The large proportion of papers being currently presented in America emphasize the need of greater understanding of the principles involved in directional solidification and in the metal-mold reaction; it is interesting to note a similar concern by the French author, as revealed by his statement: "It will therefore be seen that for any alloy or casting the principal factors governing the position and magnitude of shrinkage are the pouring factors (method,

(Continued on p. 160)

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Magnesium Foundry . . .

temperature, speed) and the metal-mold reaction, and the shape and size of the risers." The author deals with chills, their size and shape, and it is generally recommended that the cross section of the chill be equal to that of the part to be chilled. For heavy chills it is suggested that extension arms form part of the chill to assist in holding the chill in place in the sand. Further methods of chilling are suggested by the use of special sands of varied conductivity. These apply to thin sections only but of any area. On castings on which it is difficult to apply special sand or chills, a number of holes may be made in the sand, about ⅛ in. deep and 1/10 in. wide. This will result in pegs of metal forming during casting, which solidify quickly and act as cooling centers.

The next consideration is risers and various ways of controlling the heating and therefore cooling of critical points in the mold. Suggestion is made of having green sand on one side faced by dry sand on the other where opposite cooling rates are desired. The importance of not leaving the riser design to the molder but of providing riser patterns is emphasized. Detailed methods of risering with full discussion of heat transference are given and ample diagrams are provided.

In dealing with casting design the author emphasizes the importance of its effect on the temperature gradient of the mold. The more the design is planned with this gradient in mind the less need there will be for such expedients as chills and risers. Attention is drawn to the bad effect of very small amounts of carbon in the molding sand. An example is given of 80% rejection of one lot of castings because the railroad car of sand had been standing uncovered on a siding by the side of a coal storage.

Four stages are described that result in hot tears, and perhaps this is best reported by quoting the author: "The stages by which a hot tear occurs – and the process is the same for all alloys with a solidification range – are as follows:

"1. As soon as the metal begins to solidify the presence of primary

(Continued on p. 162)

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You can rest assured that if the chrome-iron or chrome-nickel castings you order from us require any welding, it will be done skillfully.

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EASTERN OFFICE 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE 332 South Michigan Avenue

Magnesium Foundry . . .

crystals in the melt renders it viscous. Since viscosity has not yet progressed enough to prevent the melt from collapsing, shrinkage porosity begins to develop on the surface.

"2. Viscosity becomes more marked, especially near the walls of the mold, which, as they solidify, tend to resist collapse. A second zone of internal shrinkage porosity is then entered. With magnesium, which is a good conductor but not very fluid, these cavities usually take the form of microporosity.

"3. The metal continues to shrink; simultaneously the network of crystallized metal grows and encloses metal which is still in the liquid phase. Hot tears may then appear in the solid part of the melt, but they will be surrounded by sufficient liquid metal to close up the cracks as fast as they form. Some will remain partially visible. These are the sinks so frequently met with in magnesium. They have a streaky appearence and are usually to be found at the fillets around bosses and in the vicinity of massive sections. They are difficult to eliminate, and the use of chills is often imperative.

"4. When solidification is complete the network of crystals will be sufficiently compact to retain the liquid portion by capillary action. The hot tear, properly so called, is present in its entirety."

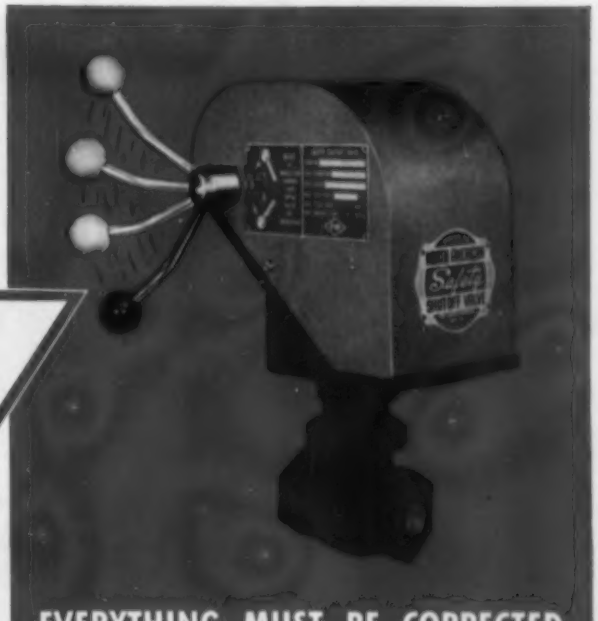
Warning is given as to making an imperfect diagnosis from observed data. The fact is that a defect will frequently result from a combination of several causes. Recurring defects are dealt with. By this is meant trouble that crops up from time to time in a repetition casting that for the most part is satisfactory. No reason is found and in a short time the trouble disappears. It is likely that the trouble is with the scrap derived from gates and risers; however, merely increasing the amount of virgin metal in the charge will not end the trouble. Melting and pouring result in a metal of lower quality than the original virgin ingot. This being so, the fact that sometimes the weight of gates and risers is more than the casting means a steady deterioriation of metal.

This state of affairs can be im-

(Continued on p. 164)

Only The North American Safety Shutoff Valve Offers a

Universal Mounting THAT FITS ANY LOCATION!



Cramped space needn't deprive you of the best explosion protection! This North American Series 22 Automatic Safety Shutoff Valve can be mounted on any fuel line serving any size or type of furnace, in almost any position.

Its compact design requires minimum clearance and minimum space between flanges. For remote control, a chain and reset wheel combination is available. Also available is a weatherproof cover.

EASILY ACCESSIBLE. Just remove two screws to get at the entire mechanism for adding auxiliary signals, for easy checking, or for quick servicing.

SAFEGUARD YOUR FURNACE with the safety valve that offers maximum protection with minimum fuss — made by NORTH AMERICAN!

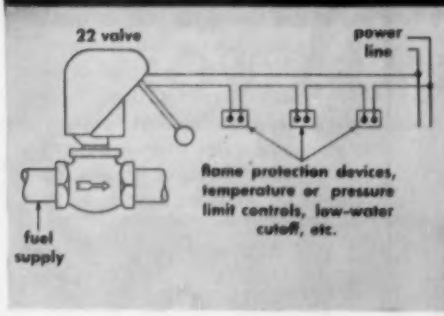
The **NORTH AMERICAN** *Manufacturing Co.*
COMBUSTION ENGINEERS
Cleveland 5, Ohio

EVERYTHING MUST BE CORRECTED
before valve can be reopened

FM APPROVED UL

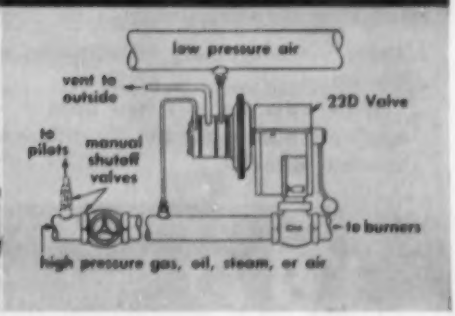
SHUTS FOR SURE in any position

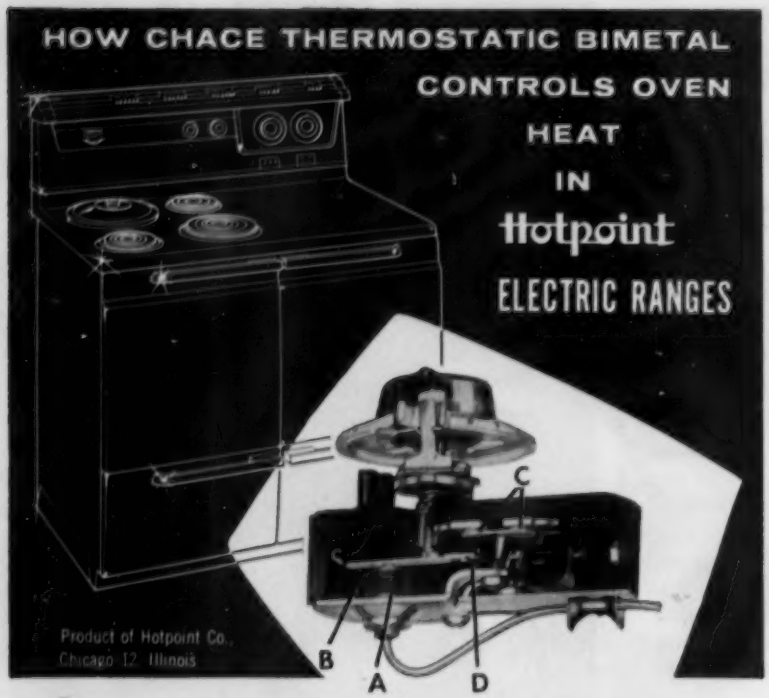
CAN'T RESET
till everything's set right



FOOLPROOF FOREVER:
never fails, tires or forgets

STOPS FUEL FLOW INSTANTLY!
no matter what goes wrong





During the last fifty years, the Hotpoint Company has pioneered in the development of the electric range to its present highly refined state. Naturally, dependable regulation of oven temperatures is essential to efficient operation. Therefore, the Hotpoint range depends upon Chace Thermostatic Bimetal as an integral part of the temperature controlling thermostat.

The Hotpoint thermostat functions to control oven heat by two means: an oven-mounted sensing bulb reacts to a preset temperature by the expansion of contained fluids which impart a force on the expansible and contractible bellows assembly (A), and on the operating blade (B), to break the circuit of the double pole contacts (C), with a snap-action.

Since much of the fluid contained within the bellows assembly is *exterior* to the oven and subject to the expansion and contraction effects of extraneous temperatures, Chace Thermostatic Bimetal (D) is employed in a section of the operating blade to function as an automatic compensator for eliminating the effects of undesired temperature sensing. Its flexing adds to or subtracts from the forces of curvature of the operating blade depending upon whether the temperature is below or above the design base—average room temperature.

Prolonged oven operation will cause a temperature build-up in the range backsplasher (as high as 200° F.) so that the range, if not provided with a compensating Chace Thermostatic Bimetal element, would supply temperatures some 120° F. lower than desired.

Write now for our free booklet containing design and application data for the 29 different types of Chace Thermostatic Bimetal.

Magnesium Foundry . . .

proved to the extent that the ratio of casting to gates and risers can be increased. The placing of risers at different points requiring less metal in them and the elimination of others are steps in the right direction. A warning is issued about sand being left on gates and risers; this enters as silicon into magnesium. The effect of continual remelting on metal quality is demonstrated mathematically and at some length.

Pouring systems are described in great detail and with numerous diagrams; the main objective is to keep out dirt and avoid turbulence.

It is emphasized that the design of a casting must be a compromise between the imagination of the designer and the realities of the foundry. The philosophy of the designer should be to conceive simply, draw uniform sections, and think in terms of the foundry. Many aspects of this designer-foundry relationship are considered; it is worth-while reading. In regard to "running systems", it is best to quote the author, at least in part: "The problem with which the practical man is faced almost daily is: Given a casting defined by a pattern, what 'running' system is called for and how is it to be calculated? By what guiding principles are choice and calculation determined? It is of course a fact that the literature on the subject abounds in all manner of indications and observations. It discusses all the pouring methods and describes all the gating systems. But if a clear explanation, a proof, a demonstration is asked for, then all that is offered usually is a gratuitous assertion coupled with an uninteresting opinion.

"The truth is that too often routine still rules in all departments of the difficult craft of molding, and pouring and chilling afford no exception to the rule. Bottom pouring is adopted because it has always been used. How many molders know why? How many of them have a precise idea as to what happens to a stream of metal when it enters the mold? What foreman could explain except by intuition, how and why a mold should be chilled?"

A mathematical analysis is given to show how gates should be locat-

(Continued on p. 166)

Olympic FM

DIE STEEL . . . used on

Roto-Flo Spline Rollers

SAE 1040 splines being cold formed.
Photo courtesy Michigan Tool Co.

Michigan Tool Co., Detroit, selected

Olympic FM for this severe cold forming application

On the new Roto-Flo Spline Rollers manufactured by the Michigan Tool Company, Latrobe's Olympic FM Die Steel has been specified for use in the cold forming racks shown above. This is a severe application involving heavy pressure to cold-form steel splines, serrations and similar shapes . . . an application that demands up to 150,000 production pieces before the racks are removed for regrinding.

Olympic FM . . . one of Latrobe's new free-machining high carbon-high chromium die steels . . . has proved extremely successful on long production runs of all types of tools and dies. In addition to long performance characteristics, Olympic FM yields a superior machined finish and easier machinability . . . factors resulting from the addition of alloy sulphides uniformly dispersed by the DESEGATIZED® process of manufacture.

For improved machinability and long production runs, order Olympic FM . . . over 250 sizes are stocked in ten conveniently located warehouses. Your order will be handled promptly and courteously.

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*10% in the case of Permabrasive
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Magnesium Foundry . . .

ed, preferably where the large dimension is vertical. The number of gates should be multiplied in order to increase their total area and consequently the volume of feed. A correct pouring system should produce a tranquil distribution of the metal. One method that is given for calculating a "running" system is based on fundamental equations. To be of any use this example must either be given in its entirety or left to the reader's interest to secure the series of articles themselves; space limitations makes the former impossible. Values are tabulated for the relationship of pouring rate to size and number of gates, and also for the relationship between volume of down-gate and the depth of drop. Pouring basins having down-gates at two different levels are illustrated and reasons are given for their use. The use of the spirit level is advised to insure horizontal running of metal in the sprues, and, on occasion, the tilting of the mold to help control the speed of entry.

In closing, the author again emphasizes the steps that must be taken to control the cooling of the metal to all parts of the casting as long as that part requires it. As he says, "The chilling of a casting therefore is no simple matter. It is not enough, as some technicians think, merely to place a few chills against those massive sections which depart from the general homogeneity of design. This local chilling of the massive sections must be superimposed on a general system of cooling . . . The following features are present in every mold: a heat center, that is the ingate; a center at which the cooling proceeds slowly; the riser; a center at which cooling is rapid; this is present somewhere in the mold. The first two can be determined by the foundryman; the third depends mainly on the shape of the casting. . . . We see how intimately connected the positions of these three centers are, the judicious determination of which is probably the most delicate problem confronting the technician. The latter should be able to foresee the consequences of interactions which normally elude calculation and which in the main must be interpreted by common

(Continued on p. 168)

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LIGHTNIN Mixers for quench baths are recommended by major steel companies; used in many plants. You can use LIGHTNINs for standard quenching, martempering, austempering; for batch or continuous processing; in new or existing quench tanks. You can get LIGHTNINs in many types and sizes up to 500 HP per unit.

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Magnesium Foundry . . .

sense and experience. In this respect the molder is something of an artist. . . . It is the foundryman's job to discover the most effective technique. Faced with an infinite number of special cases, each of which is a part to be cast, it is impossible to formulate a precise rule. As has already been emphasized, it is the expert eye allied with common sense and experience, which provides the best rule".

This reviewer has been much impressed with the sound reasoning of Mr. Caillon in this series.

H. J. ROAST

Graduate Training . . .

(Continued from p. 85)

rollments. In one large metallurgy department 30% of all foreign graduate students have remained in this country and have thus been added, temporarily or permanently, to the man-power supply.

It is probable that about 150 to 200 Masters' degrees in metallurgy will be conferred annually in the next few years.

This forecast has not been reached by elaborate techniques, but is nevertheless presented with some confidence. Approximately one quarter of these will continue graduate studies and 10% should be deducted for foreigners returning to their countries. Thus, the number of men with new Masters' degrees available for employment will be approximately 100 to 135 per year. A sizable fraction of these persons are already employed and will continue in their positions.

The number of Doctors' degrees in metallurgy to be granted in the next few years will probably be in the range of 60 to 80 per year. The fraction of men already employed will be smaller than for the Masters' degrees; a 10% deduction for foreign students should again be made.

The speculative nature of these forecasts should be emphasized. Also, any future comparison with actual figures should be on a comparable basis. That is to say, they will have to be collected directly from the educational institutions, unless the published statistics are greatly improved.

The TIMKEN Company reports:

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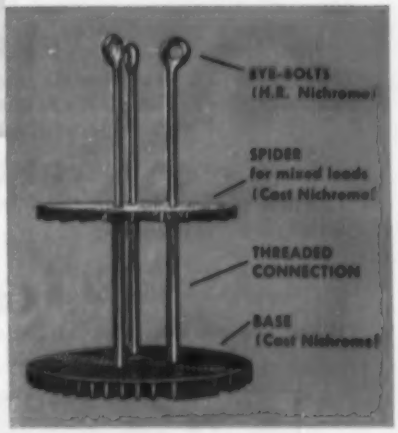
Carburizing-Quenching Fixtures Operating at 1700°F.

LAST UP TO 4300 HOURS

This Nichrome fixture carries 4200 lbs. of Timken Tapered Roller Bearings into a carburizing furnace at 1650-1700° F. for 16 to 96 hours; then both fixture and load are oil quenched. The entire weight of fixture and work load — over 4700 lbs. — is suspended from 3 Nichrome eye-bolts. These Nichrome fixtures subjected to this punishing thermal shock, in continuous operation, last up to 6 months.



Nichrome heat-treating fixtures will give you, year in and year out, the lowest obtainable heat-hour costs. For nothing but this high nickel and chromium alloy will come anywhere near the endurance records made under the most severe conditions in plant after plant the country over.

Also, because this is so, the Driver-Harris engineers have acquired a wealth of experience second to none, in designing fixtures to give you the widest possible usefulness. These fixtures for The Timken Roller Bearing Company, for instance, are built so that the same fixture will carry either single or mixed workloads.

It is certain that *you* want the same thing that The Timken Company wanted — the lowest possible heat-hour costs. The answer to *your* situation may be found in the alloy Nichrome, or it may be a matter of a more practical design for your fixtures — or both. Ask for our recommendations — low heat-hour costs are our specialty.

*T. M. Reg. U. S. Pat. Off.

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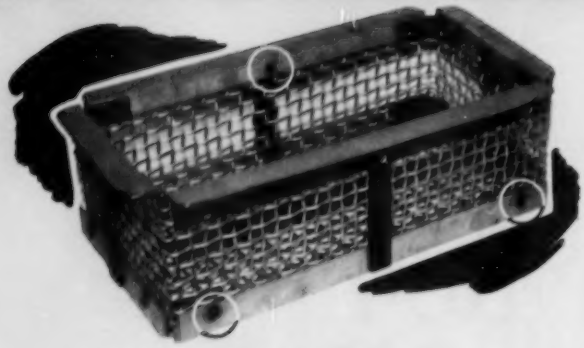

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"Using only 11 Interlock baskets, we saved $19,360 in 18 months, even though the Interlock unit-cost was almost twice that of old equipment."
—Electrical equipment manufacturer

✓ PROOF

"Our first 15 Interlock units look like new after constant use in carburizing and oil quenching . . . please fabricate 30 more units."
—Automobile manufacturer

✓ PROOF

"We've had no down-time since we started using Interlock."
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Fatigue of Aluminum Alloys*

FATIGUE failures in aluminum alloys originate from minute fissures that result from concentrated dislocations along slip planes in certain grains. On repeated stressing the fissures join to form cracks that can be recognized with a microscope. The detection of such cracks might serve as a means of estimating the life of a fatigue test specimen without waiting for the completion of a long test.

The endurance limit values for aluminum alloys, based on withstanding 5×10^8 cycles of stress in a rotating-beam test without failure, do not vary between different alloys as much as the tensile and yield strengths. For instance the endurance limits of wrought alloys range from about 15,000 to 22,000 psi., whereas the yield strengths range from about 10,000 to 80,000 psi. Although various sand-cast alloys have yield strengths from below 10,000 to 40,000 psi., their fatigue strengths are all about 10,000 psi.

The fatigue strength of aluminum is affected by the method of testing in the same way as that of any metal, direct stressing giving somewhat lower values than the use of a rotating beam or repeated flexure. Stressing in compression only gives longer fatigue endurance than when the same stresses are in tension. Several of the usual approved methods of specimen preparation are satisfactory, but the fatigue strength of fully annealed aluminum of high purity can be determined only in specimens annealed after cold working and machining; otherwise the specimen preparation affects the results. In spite of apparent care in specimen preparation and testing, fatigue results on aluminum alloys at different laboratories may vary appreciably. Also the results obtained for a single curve normally show more scatter than is expected with other metals. Averages of curves collected from numerous tests are thus necessary for reliable data, and the data are best reported as a scatter band or range of values,

(Continued on p. 172)

*Digest of "Fatigue of Aluminum", by R. L. Templin, a lecture presented at the Chicago Meeting of the American Society for Testing Materials, June 15, 1954.

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The technical know-how of Murray-Way's experienced engineers is the reason that production men who want a BETTER WAY . . . SPECIFY MURRAY-WAY.

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Aluminum . . .

rather than a single average value, for each alloy.

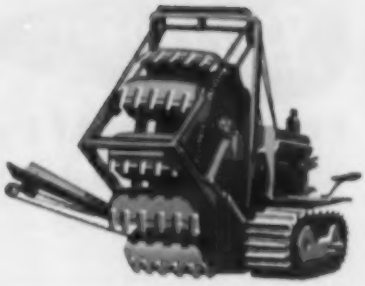
A comparison of typical fatigue curves for the strongest aluminum alloy, 7075 (75 S), with those for steels, titanium and magnesium is exhibited for smooth and notched specimens, respectively. The endurance ratio for this aluminum alloy is only 0.27, lower than that of any of the other materials. The endurance limit for smooth specimens is between those for S.A.E. 1020 steel and AZ 80 magnesium, which is the lowest of all; for notched specimens it is between those for 150 A titanium and AZ 80 magnesium. Aluminum alloys may differ widely in composition without much difference in fatigue strength.

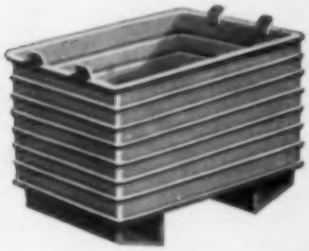
Aluminum alloys cast in permanent molds have slightly higher fatigue strengths for smooth specimens than the sand-cast alloys, but with notched specimens there was no significant difference. Die castings have higher fatigue strengths, equal to those of the wrought alloys. Notches lower the fatigue strength of sand castings only about 17%, but the decrease resulting from notching of permanent-mold castings averages nearly 40%. The fatigue strength of notched specimens of aluminum alloys is about the same whether cast or wrought bars are tested. Good ingot quality is very important for high fatigue strength. Fatigue test curves obtained over a period of 17 years show satisfactory consistency, the spread in results being within 5000 psi.

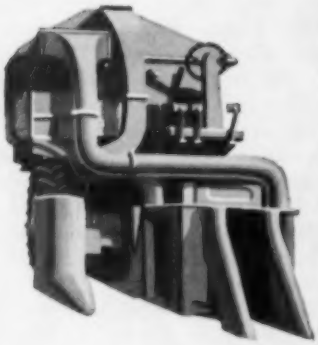
Cold working raises the fatigue strength for smooth specimens, though not as much as it raises the tensile or yield strength, but it does not affect the notch-fatigue strength appreciably. A solution heat treatment applied to a heat treatable wrought aluminum alloy increases the fatigue strength, often as much as 50%, but precipitation hardening does not improve the fatigue strength further.

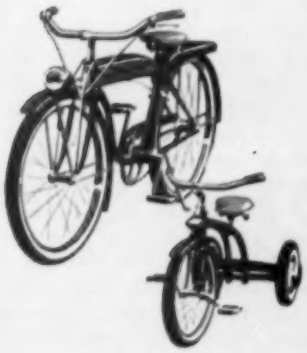
Grain size and direction probably have no significant effect on the fatigue strength of aluminum alloys. The particles of intermetallic compounds in these alloys also do not affect the fatigue strength, even when segregated. Seams, porosity

(Continued on p. 174)









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Aluminum . . .

and similar defects impair the fatigue strength of smooth specimens, but not as much as surface irregularities such as tool marks. On notched cast specimens the effect of porosity is negligible.

Internal compressive stress may double the notch endurance limit of an aluminum alloy, and internal tensile stress may reduce it by 50%. The strains produced by stressing to less than half the tensile strength have little effect.

The fatigue strength of aluminum alloys generally increases at low temperatures, and in castings does not decrease much at temperatures up to about 300° F. Above that temperature the decrease is greater. Differences between the alloys in fatigue strength become unimportant above about 600° F.

The effect of the size of the fatigue specimen between ¾ and 4 in. is not significant for aluminum alloys.

A thick, hard surface coating, such as the anodic coating formed in sulphuric acid baths, may decrease the fatigue strength. Alclad coatings have a similar effect, as do some of the other plated metals.

The fatigue strength of aluminum alloys is decreased by corrosion as well as by stress-raisers such as tool marks, scratches and holes. The amount of the decrease is often much less than would be anticipated from the calculated stress concentration, but may be as much as 50 to 60% of the unnotched value.

Fatigue curves are presented for various types of joints in different alloys. The tensile strength had an influence on the fatigue strength up to about 10,000 cycles, but above 1,000,000 cycles the fatigue strengths of all the alloy joints were around 10,000 psi. Changes in joint design may greatly affect the fatigue strength. The comparison of different kinds of joints on the basis of fatigue strength is, however, affected by the method of presenting the data. An example shows that when the number of cycles to failure was plotted against load per inch of joint width, a welded butt joint had better fatigue strength than a riveted double-strap butt joint of the same gross area in the same aluminum

(Continued on p. 176)

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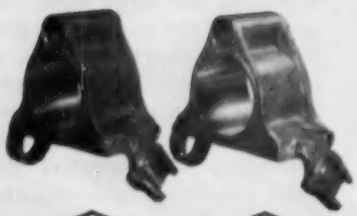

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Aluminum . . .

alloy; but when the number of cycles was plotted against the net stress, the riveted joint was superior up to 10^7 cycles. The fatigue strength of actual structural components may be from ⅛ to ¼ that of smooth test specimens of the same alloy. Typical reduction factors are presented for a number of special forms and discontinuities. Lap joints generally have about half the fatigue strength of double-strap butt joints. The best rivet spacing for fatigue strength is about three times the rivet diameter. Mismatched rivet holes impair the fatigue strength and should be avoided.

There is need for more work on the fatigue strength of aluminum alloys under combined stresses and with various stress-raiser configurations, or in the form of commonly used structural components.

G. F. Comstock

Self-Diffusion of Fe in the Fe-Ni System*

Data on the effect of alloying elements on self-diffusion give information on the binding of atoms in the lattice of a solid solution and indicate the mechanism of diffusion. Gruzin previously studied the effect of carbon on the self-diffusion of iron in austenite and concluded that the binding of the iron atoms decreased with increase in the carbon content. The present work was designed to explore this matter further in a binary iron-base alloy. The iron-nickel system was chosen for the study because nickel forms a solid solution with carbon and because nickel widens the range of concentrations over which gamma iron exists, thus reducing any complications which could be caused by phase transformations.

The alloys used contained 19.65 to 25.0% nickel, 0.02 to 0.95% carbon, a trace to 0.1% silicon, and a trace to 0.19% manganese. After being

(Continued on p. 178)

*Digest of "Influence of Carbon on the Self-Diffusion of Iron in the Iron-Nickel System", by P. L. Gruzin and E. V. Kuznetsov, *Doklady Akademii Nauk SSSR*, Vol. 93, 1953, p. 809-812.

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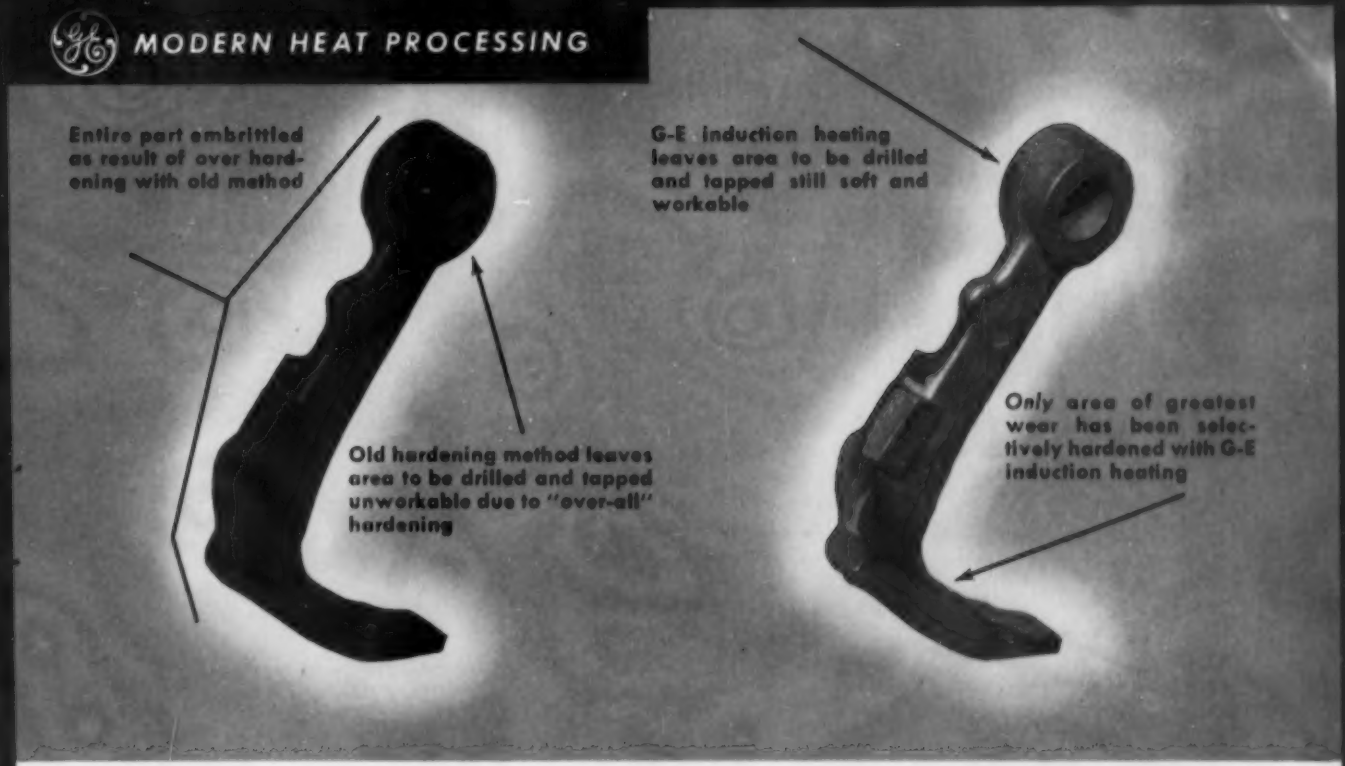
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Self-Diffusion . . .

cast, the alloys were homogenized for 20 to 25 hr. at 2200° F. in a hydrogen atmosphere. They were then forged into bars from which specimens 30 × 10 × 7 mm. (1.2 × 0.4 × 0.3 in.) were prepared. Some of the alloys were found to have a martensitic structure at room temperature while others were austenitic. All of the alloys were given about the same large grain size by a 5-hr. heating at 2425° F.

Radioactive iron, Fe^{59}, was electroplated on the polished surface of a specimen to a thickness of 0.001 to 0.01 mm. (0.00004 to 0.0004 in.) During the diffusion anneal the specimens were prevented from oxidizing by being sealed under vacuum in a quartz tube. The amount of diffusion was determined by the "integral residue" method of Gruzin.

The data obtained on the self-diffusion coefficient of iron in the solid solution containing nickel and carbon could be summarized in the following two equations, where p represents the carbon content in atomic percent:

For alloys containing 20% nickel:

$$D = (18 \times 10^{-4.0}) e^{-\frac{75{,}000 - 6000p}{RT}}$$

For alloys containing 25% nickel:

$$D = (71 \times 10^{-4.0}) e^{-\frac{79{,}000 - 5000p}{RT}}$$

A most interesting observation was the fact that the data for the austenitic alloys (for example, the alloy containing 20% nickel and 0.9% carbon) plotted as a single straight line in the customary log D versus $\frac{1}{T}$ plot, while the data for the alloys that underwent a martensitic transformation (20% nickel and 0.2% carbon) plotted as two straight lines with the break in the range 1830 to 2010° F. A later investigation showed that the cause of the abnormallly fast diffusion in the low-temperature range was a multitude of internal surfaces existing in the austenite grains as a result of the prior martensitic transformation.

It was concluded that carbon decreases the binding of iron to the iron-nickel solid solution and that this effect is smaller the higher the nickel content of the alloy.

A. G. Guy

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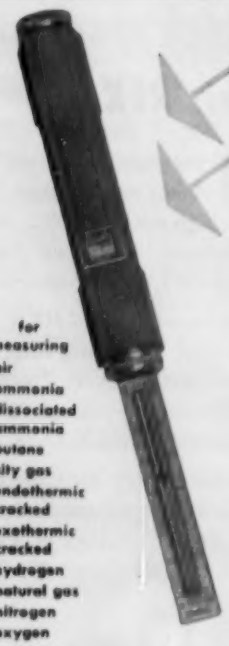

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Growth of Graphite Nodules*

THE GRAPHITE nodules formed during annealing of white cast iron are irregularly shaped in comparison with the equi-axed "spherulites" that form during the crystallization of magnesium-treated (nodular) cast irons. To study the cause of this difference, a white cast iron, melted in a high-frequency electric furnace, was modified with magnesium of 95.23% purity and cast in earthen molds as cylindrical rods 20 mm. (0.8 in.) diameter. Composition of this iron was 3.03% C, 0.50 Si, 0.30 Mn, 0.09 P, 0.009 S, with 0.047, 0.076, and 0.093% Mg. These alloys were then annealed at 1560, 1740, and 1920° F. to cause formation of the graphite nodules known as temper carbon.

The course of graphitization was followed by examining specimens that were removed at appropriate times from the annealing furnace and air cooled. The microstructures were observed under polarized light, to show the direction of growth of the radial crystallites that composed each nodule. It was found that equi-axed nodules were formed only if they grew in austenite, not in contact with a carbide particle. If a portion of a nodule adjoined a carbide particle, that portion did not grow, although the other parts of the same nodule in contact with austenite did. When this happened the final nodule was irregular in shape.

Bunin and co-workers had previously shown that the controlling factor in the growth of graphite nodules during the annealing of white cast iron was not the diffusion of carbon atoms to the nodule, but rather the diffusion of matrix atoms away from the nodule. The results of the present study support this view, since a carbide particle is an excellent source of carbon atoms but is also a barrier opposing the diffusion of matrix atoms. Other support for this idea is given by the fact that graphitization is accelerated in an austenite-carbide matrix

(Continued on p. 182)

*Digest of "The Form of Nodules of Temper Carbon in Magnesium Cast Irons", by K. P. Bunin and A. V. Chernovol, *Doklady Akademii Nauk SSSR*, Vol. 95. 1954, p. 785.

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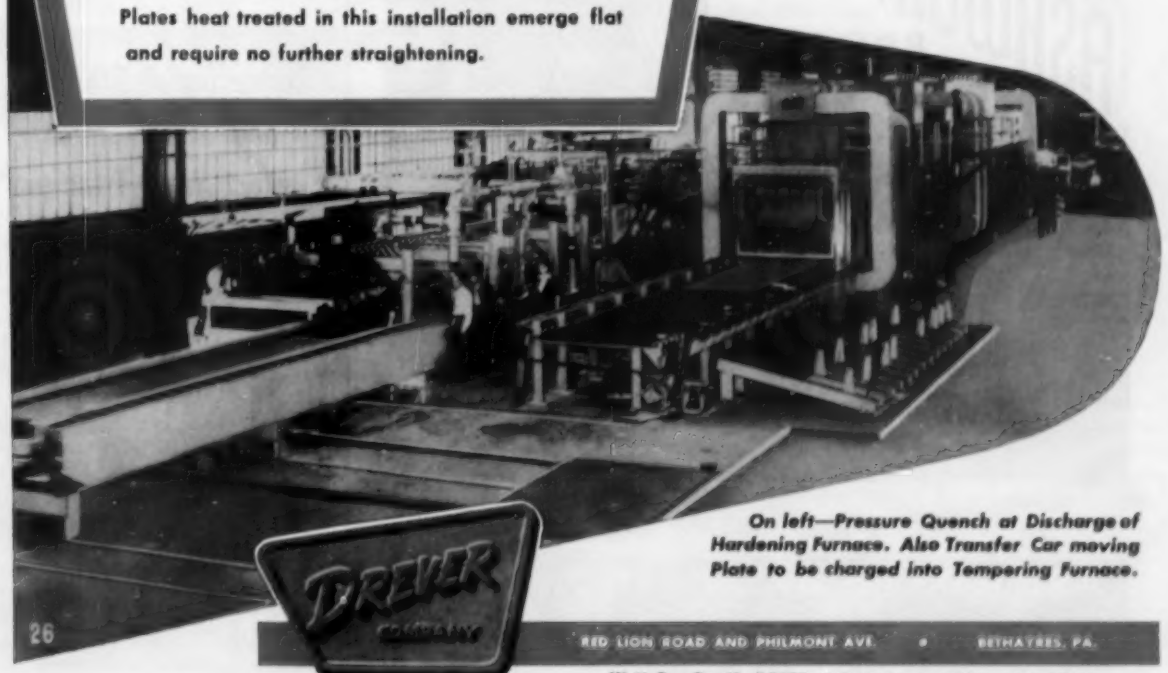

On left—Pressure Quench at Discharge of Hardening Furnace. Also Transfer Car moving Plate to be charged into Tempering Furnace.

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Graphite . . .

that contains discontinuities, since in this case only diffusion of carbon is required to form graphite in the voids in the structure. The fact of "superfast" graphitization has been established for iron-carbon powder compacts, for cast iron containing quenching microcracks, for cast iron that contains micropores, and for graphite forming on the surface of a specimen.

In ordinary white cast iron the diffusion of iron away from a growing nodule is faster along grain boundaries. This phenomenon does not occur in magnesium cast irons since the magnesium concentrates at the grain boundaries and in some way inhibits the preferential grain-boundary diffusion of the iron.

It was found that the growth of graphite nodules was faster in primary austenite (that is, austenite formed during solidification of the cast iron) than in the secondary austenite that forms from carbide particles during annealing. This fact was attributed to the action of alloying elements that preferentially crystallized in the carbide and are therefore present in the secondary austenite and decrease the rate of removal of matrix atoms.

A. G. Guy

Corrosion of Stainless and Aluminum in Contact With Titanium*

The corrosion reported in this paper was caused by intermittent exposure to sea-water spray for one year. Two kinds of titanium were used, namely, ⅛-in. thick disks of commercially pure 1-in. rounds containing 0.02% carbon, and threaded ½-in. bars and 16-gage hot rolled sheet produced from Du Pont sponge containing 0.6 to 0.8% carbon. Fourteen specimens were tested separately, and 53 in

(Continued on p. 184)

*Digest of "Corrosion of Stainless Steel and Aluminum Alloys in Contact With Titanium", by C. Braithwaite, Royal Aircraft Establishment Technical Note Met. 192, February 1954, p. 11.

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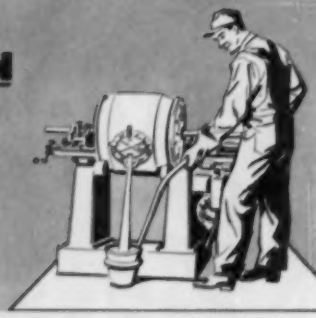

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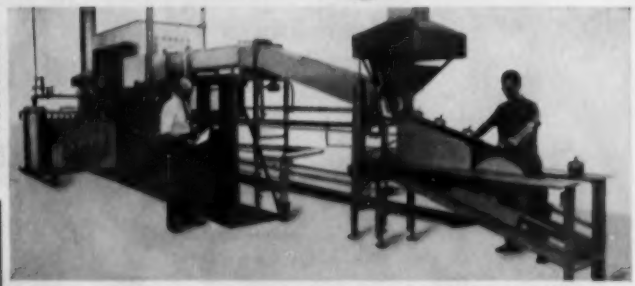

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Corrosion . . .

contact with sheets 0.036 in. thick of stabilized 18-8 stainless steel, or of a duralumin-type aluminum alloy containing 4% copper. Some of the aluminum alloy samples were anodized. Contact was made with threaded connectors and checked electrically. Some specimens were protected by a jointing compound consisting of an oil varnish pigmented with a mixture of 50% kaolin and 50% barium chromate.

All the titanium specimens were completely resistant to corrosion in this sea-water spray test. Whether the titanium was machined, or polished, or scaled by annealing made no difference. The stainless steel in contact with titanium was slightly pitted except for the protected specimens, which were unaffected. The unprotected aluminum in contact with titanium was seriously corroded in every instance, even though it was not always apparent at the outside of the joint. Again, the pigmented varnish protection was effective in restricting the corrosion to a negligible amount. The anodized aluminum was somewhat less corroded than the unanodized. Metallographic examination of the corroded aluminum samples showed that pitting and intercrystalline corrosion were much worse near the titanium contact.

Seven plates of photographs of corroded specimens are exhibited, but are rather unsatisfactory. Darkened areas in several photographs are stated not to represent corrosion although the appearance is the same.

It is concluded that corrosion of stainless steel will occur inside unprotected joints in contact with titanium and sea-water spray, and that serious corrosion of aluminum alloy sheets will occur at the interface of joints with titanium under similar conditions. Anodizing of the aluminum is helpful, and when the joints are protected by a varnish pigmented with kaolin and barium chromate, corrosion of the aluminum alloy in a year in contact with titanium and sea-water spray should be negligible.

Similar tests of riveted joints are in progress, using other aluminum alloys, stainless steel, Monel, and cadmium-plated mild steel, with titanium. G. F. COMSTOCK

Tool Steel Topics

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2 Fine Tool Steels Team Up to Make Compound Die

This compound blanking, forming and piercing die is used by National Motor Bearing Co., Redwood City, Calif., in the production of cup cases for oil seals. The die is made up of two grades of Bethlehem tool steel: BTR and Lehigh H.

Hardened to Rockwell C 60-61, the long-wearing die forms the cup cases from plain carbon steel, stainless steel, and brass sheets. They range in diameter from ½ in. to 14 in., and in thickness from 0.030 in. to 0.090 in. The die produces parts to tolerances of plus or minus 0.002 in., and produces up to 75,000 pieces before slight redressing is required.

BTR (Bethlehem Tool Room) is our general-purpose, manganese-chromium-tungsten grade of oil-hardening tool steel. Its main feature is its safe-hardening property. This, coupled with its sound combination of wear-resistance and toughness, makes BTR an ideal steel for all general-purpose tool and die applications.

Lehigh H is a high-carbon, high-chromium tool steel. It offers maximum wear and minimum distortion in heat-treatment. It is also a deep-hardening steel, in air, and thus has high compressive strength.

Your tool steel distributor will be pleased to furnish additional information about these fine Bethlehem tool steels. He'll welcome your call, right now.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Why and How to Stress-Relieve Tools

Stress-relieving is performed on tools to partially remove residual stresses resulting from machine work, mechanical straightening, hobbing, or other cold working. The reduction of stress is important in avoiding excessive distortion during tool hardening, as well as in avoiding the cracking that results from the addition of residual stress to the thermal stress produced when heating to the hardening temperature.

Stress-relieving is accomplished by heating the steel to from 1100 to 1300 F. Because of the relatively low temperature, surface protection against scale or decarburization is usually not required. As the temperature used is always below the transformation range of the steel, the rate of cooling is unimportant, except that it must not introduce thermal stress during cooling. Only a portion of residual stress is removed by this procedure. Up to the lower critical, the higher the stress-relieving temperature, the more completely is the stress removed.

The degree of stress-relief afforded in this manner is usually sufficient. However, if complete relief of stress is required, a full anneal practice should be employed, including full austenitization and slow furnace-cooling.

TUBE MANDREL FOR SERVICE IN EXTRUSION PLANT

Shown during a finishing cut, this tube mandrel will see service in the extrusion plant of Kaiser Aluminum & Chemical Corp., Halethorpe, Md. The mandrel is made of Bethlehem Cr-Mo-W (chrome-moly-tungsten) tool steel. Cr-Mo-W is an all-around hot-work steel containing 5 pct chromium. It is especially suited for jobs that involve shock and drastic temperature changes, as well as for jobs where heat-checking is a problem.

Fatigue Failure After Chromium Plating*

DURING a short marine service life the journals of the crankshafts of two V-type, 12-cylinder 400-hp. diesel engines became scored, and were reconditioned by grinding, chromium plating and grinding to size. After running 190 hr. one crankshaft broke in three pieces, the fracture extending through both webs of the crank nearest the driving end. The fracture was found to have originated in typical fatigue cracks in the journal fillets. Several other cracks had started at five similar locations toward the driving end of the shaft. They all extended along about a quarter of the circumference of the journal and then diverted into the webs. The locations and extent of the cracks are described in detail.

A metallographic examination of the broken shaft showed it to be medium-carbon steel with finely spheroidized pearlite, and free from segregation. The hardness was Brinell 200. The chromium deposit was 0.0045 in. thick and had a diamond pyramid hardness of 750 to 810. The chromium did not extend into any of the cracks in the steel, but some of the cracks extended into the chromium. The surface of the chromium deposit showed a network of fine cracks.

The existence of bi-axial tensile stress in the deposit was established by machining away most of the steel from a sample, which caused an increase in diameter of the residual surface strip. Estimates of the magnitude of this internal stress, based on measurements of the deflection of surface strips, gave values from 26,000 to 80,000 psi.

The other crankshaft, which had been similarly plated and used for 190 hr. without failure, was also examined for cracks. There were about as many present as in the broken shaft.

The failure of one shaft and cracking of both are ascribed to the chromium plating. References are given to reports of tests indicating that the endurance limit of steel may be reduced by chromium plating to only 35 to 65% of the value for the unplated steel, especially if the chromium is over 0.002 in. thick and the plating rate was fast, with high current density. This reduction is produced by residual tensile stress and cracks in the deposit, and by hydrogen embrittlement of the steel. Heat treatment at temperatures below about 400° F. intensifies the impairment of the endurance of chromium plated steel by hydrogen. Tempering at 570 to 800° F. removes hydrogen and improves the endurance.

In these crankshafts the cracks originated at locations where working stresses were concentrated, not only by the design, but also by grinding marks and plating cracks. With the additional internal stress due to the plating, the endurance limit was exceeded. The working stresses were chiefly torsional, for

(Continued on p. 188)

*Digest of "Fatigue Cracking of Two Chromium-Plated Crankshafts", British Engine Boiler and Electrical Insurance Co. Ltd., Technical Report, Vol. 2, September 1954, p. 165-177.

For maximum efficiency in the production of specimens in the metallurgical laboratory the Buehler cabinet type polishing table with companion storage cabinets represents the latest modern development of this type of equipment.

The convenience of this streamlined polishing equipment saves time and encourages the operator to produce the highest quality of polished sample.

Item No. 1511 is a two-unit polishing table with Formica top approximately 60" long x 27" deep by 30" high to table top. Two 12" swing spouts, drain, 8" diameter wash bowl, plumbing and wiring.

Recommended accessories to complete an efficient set up for maximum convenience are: No. 1512 storage cabinet with recessed light and No. 1513 supporting panel for installation above polishing desk. Or, No. 1514 floor model storage cabinet. Both these cabinets can be used together to advantage in most laboratories.

The Formica top and back on the table and cabinet is installed with a smooth Formica edge that eliminates all metal rims that may form pockets for water and dirt. Covers are held in place on the back by magnetic holders. The large 8" wash bowl is a new feature that enables the operator to use both hands in washing specimens.

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Chromium Plate . . .

there was no evidence of excessive bending, and torsional vibration may have been an important factor.

Chromium plating should not be used for parts which will be subjected to alternating stresses in service, unless the plating rate is slow, the deposits are very thin, and the parts are heat treated above 570° F. after plating.

G. F. COMSTOCK

Rupture Strength of High-Temperature Alloys*

EQUIPMENT operating at elevated temperatures is frequently subjected to some sort of temperature cycling. According to the author, data on the effect of temperature variations on rupture life are meager and confusing. In a reference cited in the paper, E. L. Robinson derived formulas for the rupture life under cycling temperature based on constant temperature data. He assumed that the amount of life expended at any temperature has a cumulative effect. In this paper are reported the results of cyclic temperature rupture tests conducted on four high-temperature alloys – S 816, M 152, 16-25-6 and A 286, to compare expected life based upon Robinson's method with actual life.

Rupture strength over a range of constant temperatures was determined for each alloy. The stress-rupture data at constant temperature were plotted as a function of the parameter T (20 + log t), where T is temperature in degrees absolute and t is the rupture life in hours. The parameter should be a constant for constant stress values.

With the exception of Alloy M 252, the rupture data for these alloys conformed reasonably well with the parameter. For M 252 it was necessary to use two curves to represent the data, one applying at temperatures under 1650° F. and the other above 1650° F. This relationship was used in calculating life under cyclic temperatures.

Three types of temperature cycles were employed, described as "rectangular", "sawtooth" and "special". In the rectangular cycle the sample was stressed at one temperature for a fixed portion of the cycle and then at a second temperature for the balance of the cycle. The load was removed during heating and cooling. In the sawtooth temperature cycle, the specimen was continuously under load while its temperature fluctuated between fixed limits about the mean temperature. The special cycle was intended to approximate certain severe temperature changes to which a gas turbine bucket might be subjected in service. The S 816 and M 252 specimens were maintained continuously under a stress of 15,000 psi. in a furnace maintained at 1500° F. At regular inter-

(Continued on p. 190)

*Digest of "Effect of Temperature Cycling on Rupture Strength of Some High Temperature Alloys", by James Miller, A.S.T.M. Special Technical Publication No. 165, October 1954, p. 53-66.

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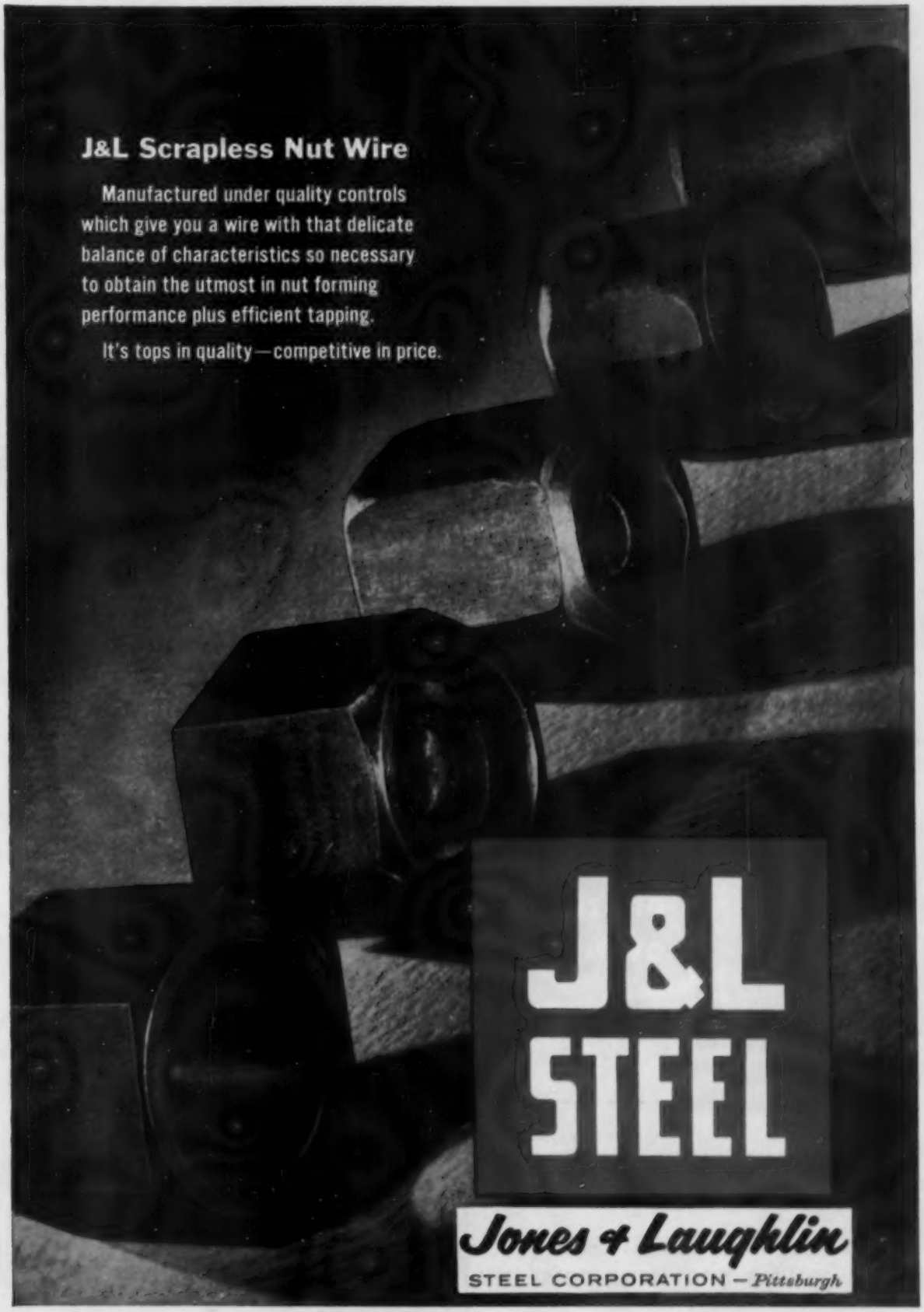
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Rupture Strength . . .

vals the temperature of the specimen was raised to 1800° F. in 60 sec. by passing a heavy current through it. The specimen was then allowed to cool to furnace temperature. In every test, a given cycle was repeated until rupture occurred.

A comparison showed that the experimental values fall somewhere between 50 and 100% of the calculated values for the test conditions. Sawtooth cycling appeared more harmful than rectangular cycling. The author states that "since the maximum difference between the observed and calculated life corresponds to a decrease in stress of only about 10%, the calculations are remarkably good and should be of considerable use if an appropriate safety factor is applied. Under conditions where thermal gradients are large enough to produce significant thermal stresses, failure could occur much sooner than might be expected on the basis of calculations neglecting such effects."

A. H. Rauch

Tensile Properties of Tin Bronzes*

In foundries solidification conditions are not favorable to homogeneity in tin bronzes and some δ phase is found in bronzes that contain as little as 7 to 8% Sn (see diagram on p. 194). Since the cooling conditions vary throughout a casting the proportion of δ constituent will also vary within the same casting.

The purposes of this study were to establish a relation between tensile properties and the distribution of alpha and delta phases in the casting, and to determine if this relation is affected by phosphorus content.

The author presents two photomicrographs of the delta constituent in a matrix of alpha. The first photograph was taken from a bronze containing 0.20% P, and the other from one containing 0.01% P. The eutectoid is more massive in the former due to compositional differences. Because of the low solubility of phosphorus in alpha phase, most of the phosphorus present is concentrated in the eutectoid. This lowers its melting point. The specimens were taken from broken test bars that had elongation values of 12.6% for the high-phosphorus bronze and 11.4% for the other. In the low-phosphorus bronze the eutectoid is cracked.

A dilatometer was used to measure the amount of delta phase. The constitution diagram shows that, upon heating, alpha plus delta are transformed into alpha plus gamma at 520° C. (970° F.) and that alpha plus gamma change to alpha plus beta at 586° C. (1090° F.). The first transformation is noticed in dilatometric experiments only if a large quantity of delta is present. On the other hand, the formation of beta is accompanied by a marked lengthening of the specimens. This increase in length is then a measure of the quantity of delta phase originally present in the specimens. The meth-

(Continued on p. 194)

*Digest of "Relation Between Structure and Tensile Properties of Sand Cast Tin Bronzes", by P. J. Le Thomas, *Fonderie*, Vol. 108, January 1955, p. 4320-4329.

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Invitation to Entrants . . .

10th Metallographic Exhibit

Entries are invited in the 10th A.S.M. Metallographic Exhibit, to be held at the National Metal Exposition in Philadelphia the week of Oct. 17 through 21, 1955. Entries will be displayed to good advantage and awards will be given for the best micrographs as decided by a committee of judges.

Awards and Other Information

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of $100, will also be awarded the exhibitor whose work is adjudged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's National headquarters in Cleveland.

All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1956 if so desired.

Classification of Micros

BLACK AND WHITE PRINTS

1. Carbon and alloy steels
2. Stainless steels and heat resisting alloys
3. Iron, cast and wrought
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5. Copper, nickel, zinc, lead and their alloys
6. Metals and alloys not otherwise classified
7. Series showing transitions or changes during processing
8. Welds and other joining methods
9. Surface phenomena
10. Results by unconventional techniques (other than electron micrographs)
11. Slags, inclusions, refractories, cermets
12. Color micros (prints; no transparencies accepted)

Rules for Entrants

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable. Photographic prints shall be mounted on stiff cardboard; maximum dimensions should be limited to 15 by 22 in. Heavy, solid frames are not permissible because of difficulties in mounting the exhibit. Entries should carry a label on the face of the mount giving:

Classification of entry
Material, etchant, magnification
Any special information as desired

The name, company affiliation and postal address of the exhibitor should be placed on the BACK of the mount.

Transparencies will NOT be accepted.

Entrants living outside the U.S.A. should send their micrographs by first-class letter mail endorsed "Photo for Exhibition—May be opened for customs inspection." To be acceptable as first-class mail the package should measure no more than 35 x 45 cm. (14 x 18 in.)

Exhibits must be delivered before Oct. 10, 1955, either by prepaid express, registered parcel post or first-class letter mail, addressed to:

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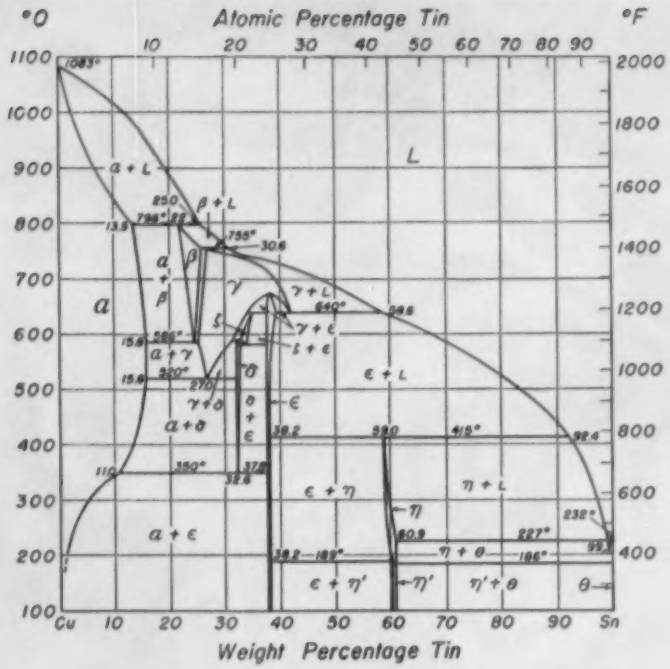
Tin Bronze . . .

od is not valid when there is enough delta to form a continuous network.

Bronzes with the following phosphorus contents were prepared: 0.01, 0.07, 0.11, 0.17, and 0.31%. Tensile test bars were cast under various conditions, and dilatometric specimens were taken from the reduced section of broken test bars. The dilatometric specimens were later reduced in chips for chemical analysis.

The results of the chemical analyses show marked variations in tin content from specimen to specimen within the same melt which caused differences in the amount of eutectoid. In order to be comparable, tensile test results must be obtained from specimens of identical phosphorus contents. The author thus presents five graphs (one for each phosphorus content) showing the relation between the ultimate tensile strength of bronzes and their thermal expansion between 600 and 750° C.

Where the phosphorus content is less than or equal to 0.07% the ultimate tensile strength decreases markedly as the amount of eutectoid increases. For 0.11% P the expansion is practically constant. When phosphorus is 0.17% and higher the tensile strength increases as the amount of eutectoid increases. The influence of delta on the tensile strength of bronzes varies with phosphorus content. The transition point between phosphorus and non-phosphorus bronzes is apparently about 0.11% P.



The relation between ultimate tensile strength and elongation is shown. The strength increases with increasing elongation. The curve for nonphosphorus bronzes is well above that for phosphorus bronzes. The former is continuous while the latter presents a definite discontinuity at an elongation of about 14%. Elongation decreases with increasing quantities of eutectoid in nonphosphorus bronzes. However, when the phosphorus content is greater than 0.11% the results are scattered. Statistical analysis shows that inhomogeneous eutectoid distribution can be responsible for the scatter in ultimate tensile strength results. The scatter is small on high or low results, very high on medium results.

Eutectoid segregation is related to the segregation of tin. The formation of eutectoid depends upon the phosphorus content and is influenced by the cooling conditions. The properties of the eutectoid influence the mechanical properties of bronzes. For a given type of eutectoid the mechanical properties vary with the amount of eutectoid present.

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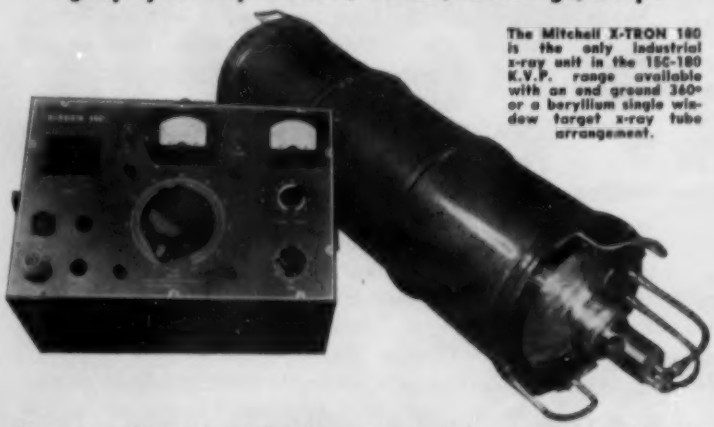

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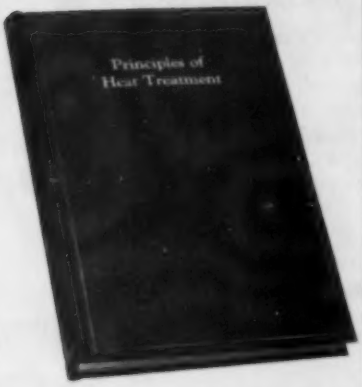

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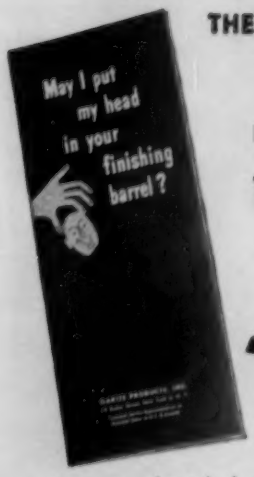

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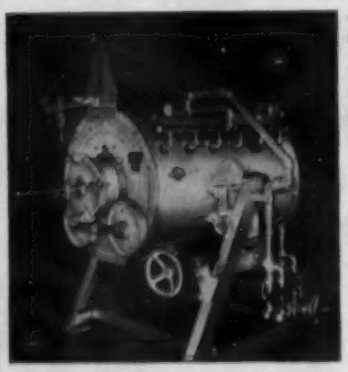

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